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SHIPBOARD WIRELESS INTERCOMMUNICATION SYSTEM: RADIAX SYSTEM DES--ETC(U)

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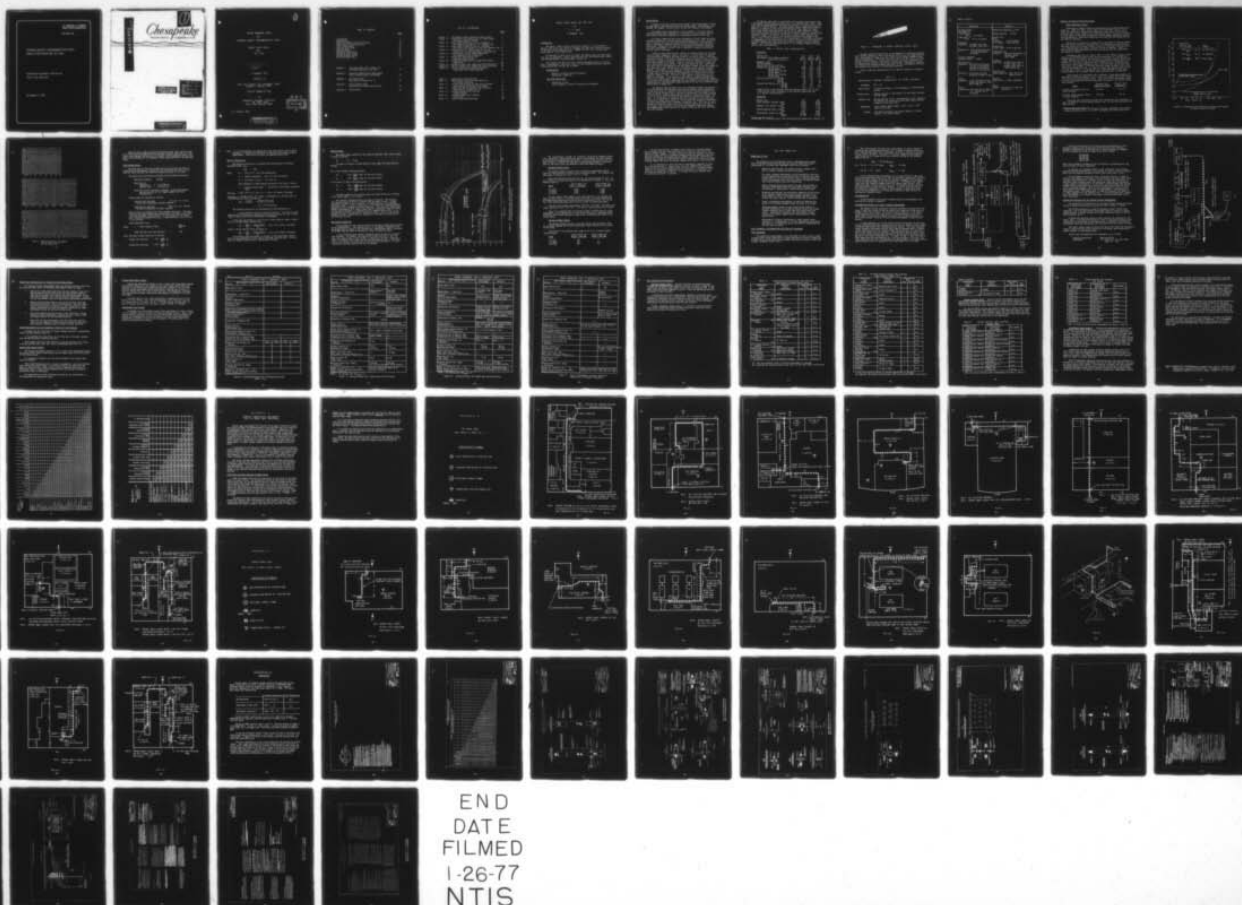
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SHIPBOARD WIRELESS INTERCOMMUNICATION SYSTEM:
RADIAX SYSTEM DESIGN AND TEST PLAN

CHESAPEAKE INSTRUMENT CORPORATION
SHADY SIDE, MARYLAND

SEPTEMBER 3, 1974

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INTERIM MEMORANDUM REPORT
FOR
SHIPBOARD WIRELESS INTERCOMMUNICATION SYSTEM

RADIAX SYSTEM DESIGN
AND
TEST PLAN

APPROVED FOR public release;
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3 September 1974

Prepared for

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TABLE OF CONTENTS

	<u>Page</u>
Introduction	1
System Design	2
Analysis of Radiax System Performance	6
Cable Radiation Characteristics	8
Total System Losses	11
Receiver Sensitivity	12
Expected Range	13
Operational Capability	13
One-Way Wireless System	15
Two-Way Wireless System	15
Test Plan Aboard Ship	17
Appendix 1 Intercompartment Cable Lengths (ft) and Cable Attenuation Loss (db)	37
Appendix 2 Shipboard Communications Measurements Prior to Radiax Cable Installation	40
Appendix 3 Aft Radiax Route Base Station at Repair No. 3	42
Appendix 4 Forward Radiax Route Base Station at Engine Control Room	54
Appendix 5 Penetrations	68

LIST OF ILLUSTRATIONS

	<u>Page</u>
Figure 1:- Photograph of Radiax Radiating Coaxial Cable	4
Figure 2:- Attenuation Plus Coupling Loss vs. Cable Length for Radiax Cable at 150 MHz	7
Figure 3:- Radiax (RX4-3) Coupling Loss vs. Frequency for Radiax Cable Taped to 1.6" Diameter Pipe	9
Figure 4:- Radiax (RN4-3) Coupling Loss vs. Frequency for Radiax Cable Spaced 1/" from 1.6" Diameter Pipe	10
Figure 5:- Received Power vs. Cable Length for Various Conditions of Transmitted Power and System Loss	14
Figure 6:- Block Diagram, Signal Strength Measuring Instrumentation and Calibration	19
Figure 7:- System Test Configuration for One-way Wireless System	21
Figure 8:- System Measurement Data and Computation Sheet, Sample Form	26
Figure 9:- One-Way Wireless Test Sample Data and Calculations	27
Figure 10:- Two-Way Wireless Test Sample Data and Calculations	28
Figure 11:- Test of Interference to Radiax Operation Sample Data for Portable Receiver	29
Table 1:- Radiax Cable Characteristics	3
Table 2:- Manufacturer's Published Characteristics for HT-220 Transceiver	4
Table 3:- Forward Route One-way Wireless Test Locations (Base Station at Engine Control Room)	31
Table 4:- After Route One-Way Wireless Test Locations (Base Station at Repair No. 3)	32
Table 5:- Two-Way Wireless Test Locations (Forward Route)	33
Table 6:- Two-Way Wireless Test Locations (Aft Route)	34
Table 7:- Emission Data Recording Sheet	36

Radiax System Design and Test Plan

by

C. J. Rubis

3 September 1974

Introduction

The report, "Radiax Cable Installation Drawings" in fulfillment of Section 1.6B (a & b) was issued on 12 August 1974 following a detailed survey of the cable route aboard the U.S.S. PHARRIS, DE 1094, by a four-man engineering team on 1 and 2 August 1974.

On the basis of that survey and report the Radiax cable and other materials such as connectors, clamps, power splitters and terminations were ordered from the manufacturer during the week of August 12.

This report, the third and final interim memorandum report in fulfillment of requirements 1.6A(a) and 1.6B(c) on the "Shipboard Wireless Intercommunication System" provides the following:

System Design

Analysis of Radiax System Performance
Operational Capability

Test Plan Aboard Ship

Objectives of Test
Test Parameters, Technical Procedures and Equipment

System Design

A means of wireless communications between closed compartments of ships has been under investigation by the Navy for many years. The methods investigated, for example, include carrier current and induction loop schemes.

The method under investigation in this contract is to use a leaky or radiating coaxial cable transmission line which acts as an antenna for two-way wireless transmission between all compartments wired with the cable.

A wireless communications system independent of ship's power and using portable, commercially available hand-held transceivers (or other variations such as worn or built into an oxygen breathing apparatus) is an excellent means of emergency communications and for use by sound and security patrols aboard ship. Because of the complete electromagnetic shielding created by the steel compartments of ships, such an approach is normally not possible without special techniques.

Effective radio communications systems are being installed in buildings (with all metal framework), tunnels, and mines. In these cases the problem of RF-shielding environment has been solved by the use of leaky or radiating transmission lines. Electrically speaking, such a transmission line is nothing more than a conductor installed inside the building, tunnel or mine which provides ready access to RF energy. Leaky or radiating transmission lines used until very recently were mostly of the balanced open wire type. Radiating from this type of line depends on the unbalanced currents in the two conductors. This makes such lines very sensitive to mounting and the effects of nearby objects. For example, if the capacity to ground of one conductor differs from the other, the radiation increases but the attenuation also increases, in many cases to the point where the attenuation is a serious limit to the practical length of line. The line is also subject to the effects of dirt, deposits, and smoke. A new version of the leaky or radiating transmission line is the slotted coaxial cable designed to radiate and receive RF signals. It possesses very distinct advantages over the balanced line and makes feasible simple wireless intercompartment communications with very low transmitted power aboard ships at modest cost.

The approach analyzed here and in the subsequent shipboard evaluation in providing the ship with emergency communication between closed compartments is the utilization of a two-way radio (transceiver) system propagating low power RF energy through leaky or radiating transmission lines routed throughout the ship (or selected compartments), thereby creating an effective "free space" for those areas served while containing the transmission within the ship. It is important to recognize that the low power of this system and shielding of normal ships cables will not provide any detectable interference to other ship systems such as weapons, navigation, etc. This lack of interference to normal ship power and control circuits operating at DC, 400 Hz or 60 Hz power, results mainly from the extreme frequency separation between the communication system operating at about 140 MHz and the other low frequency ship systems.



Figure 1:- Photograph of Radiax* Radiating Coaxial Cable

Two-way, hand-held transceivers are recommended for shipboard communications purposes because of their light weight, small size, and rugged construction. The weights of these units vary from 25 to 43 ounces, depending upon type and manufacturer. The sizes vary from 1-13/16 x 3-3/8 x 9-3/4 to 1-7/32 x 2-3/4 x 6-15/16 inches. The units are usually carried by attaching their carrying cases to the belt, not unlike a gun holster. The power is supplied by internal nickel-cadmium battery pack which is fully rechargeable and typically provides up to 8 hours of intermittent operation.

Table 2 shows the characteristics for a typical transceiver, Motorola HT-220.

Table 2.

Manufacturer's Published Characteristics for HT-220 Transceiver

Frequency:	136 - 174
Power Source:	(1) Mercury battery, or (2) Rechargeable Nickel-Cadmium battery
Battery Drain:	Standby (15V dc) 4.3 mA; Receive (15 Vdc) 65mA; Transmit (15V dc) 850mA
Battery Life:	Mercury Battery: 27 hrs., Nicad Battery: 8 hrs. (Based on 5% transmit, 5% receive with rated audio output and 90% standby in 5-watt position.)
Dimensions:	(Less antenna, knobs) HxWxD: 7.58" x 2.75" x 1.69" (192 x 70 x 43 mm)
Weight:	With Mercury Battery: 29.5 ounces (836g); with Nicad Battery: 27.6 ounces (782g).

Table 2 (cont'd)

Transmitter	Receiver
RF Output Power (Switchable): Nicad Batt @ 15V: 1 or 5 watts Merc Batt @ 12.7V: 0.4 or 2.5 watts Frequency Stability: $\pm 0.0005\%$ from -30°C to $+60^{\circ}\text{C}$ ($+25^{\circ}\text{C}$ ref.) Modulation: 16F3: ± 5 kHz deviation for 100% modulation @ 1000 Hz Crystal Frequency Multiplication: 9 times Spurious and Harmonics: More than 50 db below carrier in 5W position. More than 43 db below carrier in 1W position. FM Noise: 40 db below ± 3.3 kHz deviation at 1000 Hz tone Audio Response: ± 1 db, -3 db from a 6 db/ octave pre-emphasis from 300 to 3000 Hz Audio Distortion: Less than 10% at 1000 Hz 2/3 maximum rate of deviation.	Modulation Acceptance: ± 7 kHz Channel Spacing: 25 kHz Sensitivity - 20 db Quieting: 0.35 μV maximum 12 db SINAD: 0.25 μV maximum Selectivity -(EIA) SINAD: 70 db at ± 25 kHz Intermodulation Products: More than 60 db down at adjacent channel (EIA) SINAD Frequency Stability: $\pm 0.0010\%$ from -30°C to $+50^{\circ}\text{C}$ ($+25^{\circ}\text{C}$ ref.) $\pm 0.0015\%$ from -50°C to $+60^{\circ}\text{C}$ ($+25^{\circ}\text{C}$ ref.) Spurious and Image Rejection: More than 50 db below carrier Squelch Sensitivity: 0.18 μV , adjustable. Audio Output: 500 mW at less than 10% distortion.

Analysis of Radiax* System Performance

Cable Selection Criteria

Three types of Radiax* cable are manufactured by the Andrew Corporation (Table 1). These are: RX4-1 (1/2"), RX4-3 (1/2") and RX5-1 (7/8"). It is noted from the data on coupling and attenuation losses that if the attenuation loss due to cable length is low, the coupling loss is high and vice versa. In other words, as the cable radiates more energy thereby decreasing coupling loss the penalty is additional attenuation loss resulting from energy leaving the cable as radiation.

The choice of cable type is determined by the length of coverage needed, the coupling loss and other considerations. By computing the total attenuation plus coupling loss versus length of cable for the three different cables, it is apparent there are several crossover points as expected. Figure 2 shows a plot of the attenuation plus one way coupling loss for three different cables at 150 MHz.

Considering just the 1/2" cables, RX4-1 is a low radiation type of cable having a 75 db one-way coupling loss and an attenuation of 1.1 db/100 feet. Another type of 1/2" cable is the RX4-3 which is a high radiation type having a lower coupling loss (57 db) but a higher attenuation per foot of cable (1.9 db/100 ft.). For short lengths the high radiation cable is preferred since the sum of coupling and attenuation loss is much less than for the low radiation cable. For example, at 100 feet the total losses are about 59 db versus 76 db, a difference of 17 db. For the 1/2" cables the crossover point occurs at 2,250 feet. Thus, for coverage less than 2,250 feet RX4-3 gives lower total losses while for lengths longer than 2,250 feet RX4-1 is preferred.

Cable length and attenuation charts (Appendix 1) have been prepared for both Route #1 (aft) and Route #2 (fwd), based on the Radiax Cable Installation Plan¹ for the DE 1094 destroyer escort. From these charts the greatest length of cable and attenuation from any compartment to another is as follows (using RX4-3 cables):

<u>Route</u>	<u>Maximum Inter-Compartment Length</u>	<u>Maximum Cable Attenuation</u>
#1 (aft), Passage Main Deck to Shaft Alley No. 1	572 feet	10.4 db
#2 (fwd), Damage Control Central to Shaft Alley No. 1	419 feet	8.0 db

Note that the relationship between cable length and cable attenuation is just 1.9 db/100 ft. with no account taken of the 3 db loss when encountering a power splitter.

¹"Interim Memorandum Report for Shipboard Wireless Intercommunication System, Cable Installation Plan", 12 Aug 1974, Chesapeake Instrument Corporation

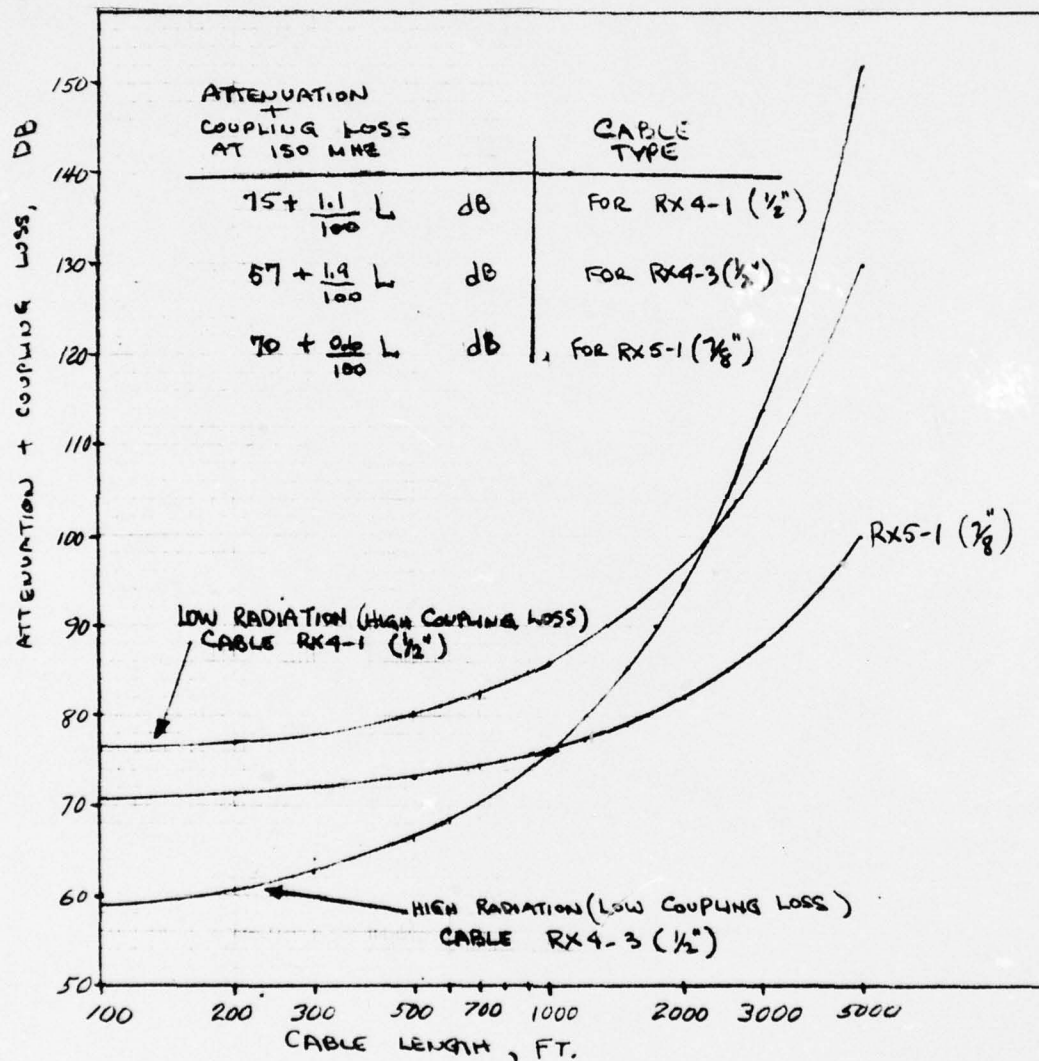


Figure 2: Attenuation plus Coupling Loss Versus Cable Length for Radiax* Cable at 150 MHz.

The total lengths are well below 2,250 feet, hence the use of the high radiation cable (RX4-3) is preferred. For example, at 572 feet the coupling plus attenuation loss indicates the high radiation cable is superior by about 13 db over the low radiation 1/2" cable.

Cable Radiation Characteristics

Recent tests (June 1974) on Radiax cable by the Andrew Corporation have indicated that radiation characteristics are affected by the proximity of metal surfaces. The type of cable most affected is the high radiation model RX4-3 with progressively decreasing effect for lower radiation cable which employs smaller size leakage holes for the electromagnetic energy.

Experimental data on coupling loss (db) versus operating frequency have been obtained for RX403 cable using 102-foot lengths and various conditions of metal proximity to the Radiax cable. This experimental plotted data is shown in figures 3 and 4.

Interpretation of figures 3 indicates large variations in cable coupling loss with frequency when the cable is in direct contact with a metal surface (in this case, a 1.6" diameter pipe). These variations can be as high as 25 db. However, the mean of the coupling loss peaks in the frequency range from 120 to 260 MHz is about 7 db. In the vicinity of 140 MHz the loss is about 1.5 db.

When the Radiax is removed 1/2" from the same metal pipe (1.6" diameter) the variations in coupling loss with frequency almost disappears (Figure 4). What remains is a coupling loss with an almost smooth variation with frequency. Coupling loss gradually increases as frequency increases. For example, at 140 MHz the loss is about 1.5 db which increases to 2.0 db at 260 MHz.

When the Radiax cable (102-foot length) is taped to a 4-1/2" diameter pipe the coupling loss variation with frequency is also pronounced, but with a mean of the coupling loss peaks of about 12 db in the frequency range of 120 to 260 MHz. At 140 MHz, the coupling loss is about 5.0 db. As with the smaller diameter pipe, when the Radiax is moved 1/2" away from the pipe, the large variations disappear leaving a loss which gradually increases with frequency. At 140 MHz and 1/2" spacing from the 4-1/2" diameter pipe, the coupling loss is about 1.8 db.

If the results of these measurements can be extrapolated to conditions aboard ship where the Radiax will follow armored metal cableways, metal bulkheads, catwalks and structural members then the problem of coupling loss variation with frequency and metal proximity can be essentially reduced to a minor loss of a few decibels by mounting the Radiax cable at least 1/2" from any metal surface.

No polarization effect is expected to take place for 150 MHz shipboard operation. Indoors, the polarization effect will be cancelled due to the multiple reflections from compartment walls, overheads, decks, and equipment contained therein. This effect has been confirmed by measurements made inside buildings; sometimes 2 or 3 db difference has been detected.

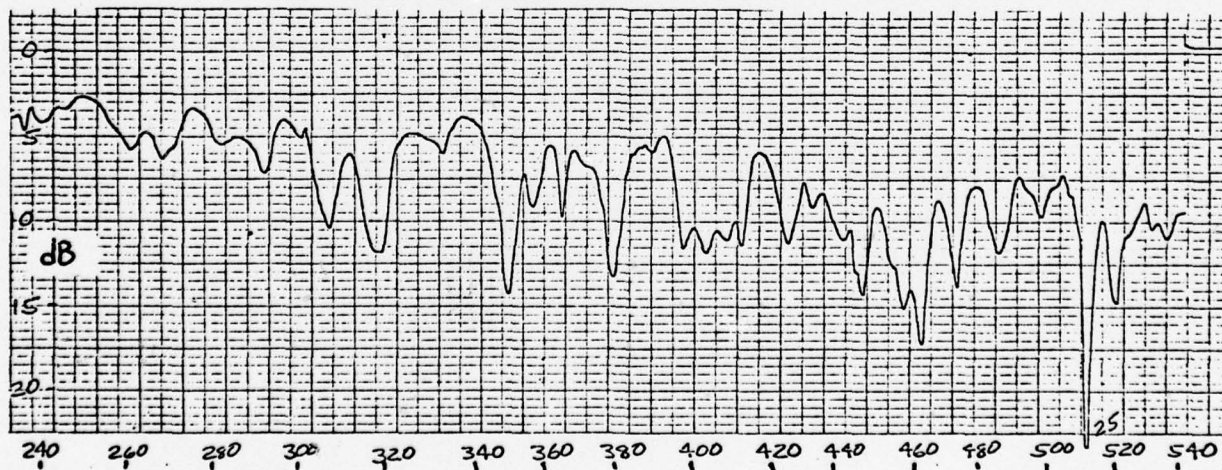
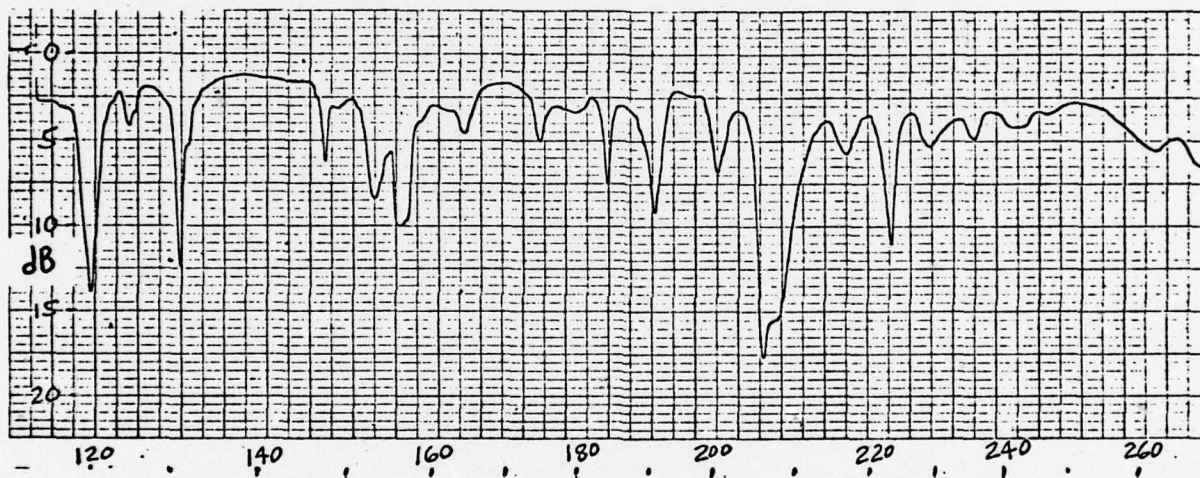
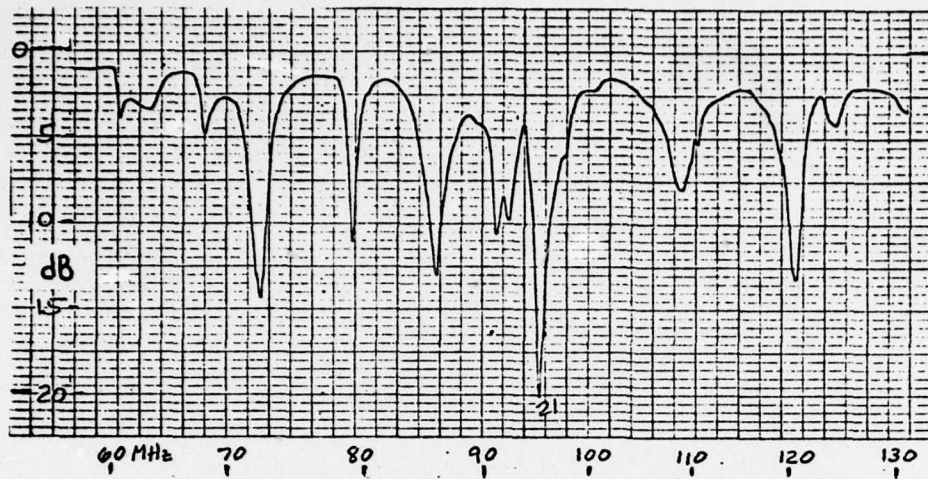


Figure 3:- Additional Coupling Loss vs. Frequency
for RX4-3 Radiax Cable Taped to 1.6" Diameter Pipe

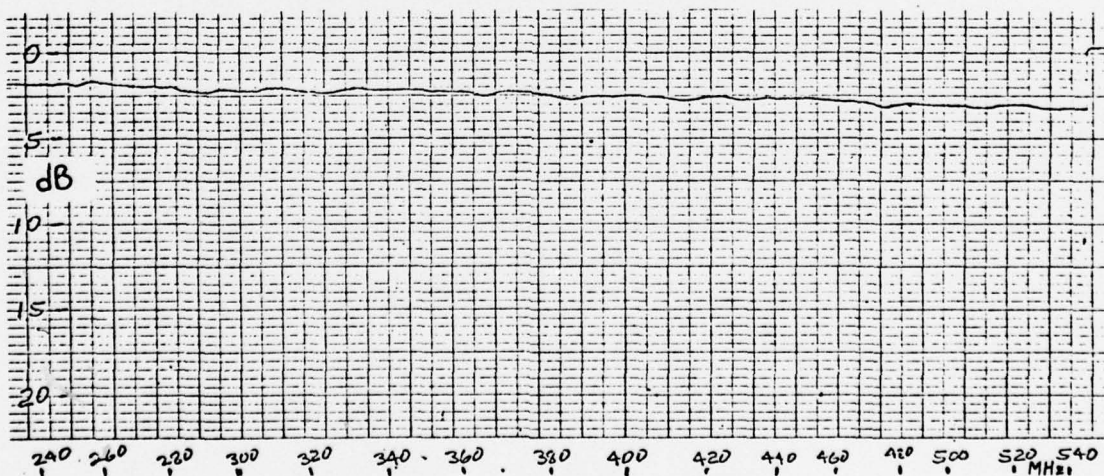
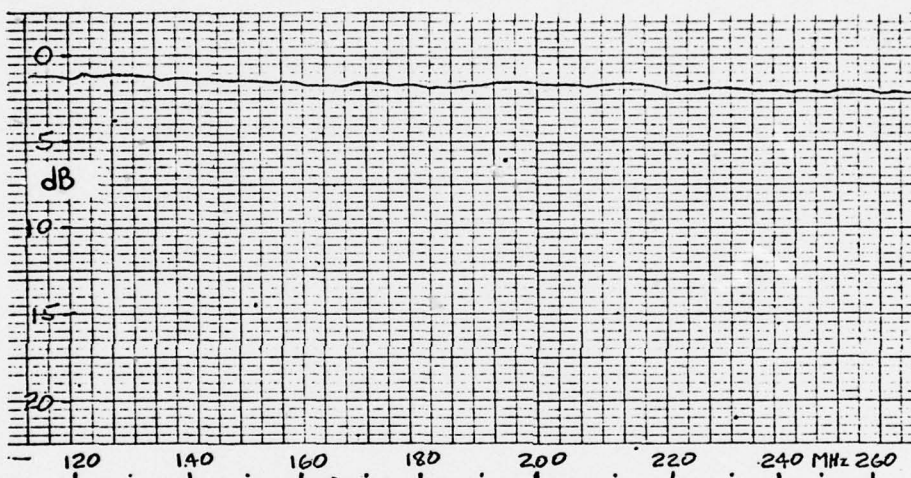
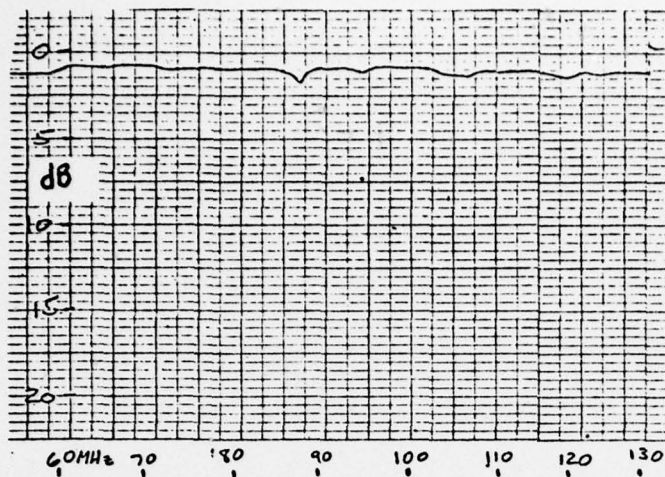


Figure 4:- Additional Coupling Loss vs. Frequency
for RX4-3 Radiac Cable Spaced 1/2"
from 1.6" Diameter Pipe

When the Radiax cable penetrates bulkheads through steel stuffing tubes or is effectively shielded by obstructing metal objects, that portion of the Radiax cable becomes ineffective as a radiator of electromagnetic energy. However, such shielding will not adversely affect other portions of the radiating cable.

Total System Losses

The major part of the total system losses are the coupling losses in transferring electromagnetic energy from the slotted coaxial cable to the receiver input terminals and from the transmitter output to the cable.

The system loss calculations are based on the following conditions:

Operating Frequency 150 MHz

Cable (RX4-3)

Attenuation = 1.9 db/100 ft.

Coupling Loss: = 57 db \pm 10 db

Unity Gain (0 db) transceiver antennas. During measurements any antenna loss will be lumped together with the coupling loss.

System losses are tabulated as follows:

Coupling loss (one way) 57 + 10 + 5 = 72 db
(hard wired transmitter, wireless receiver)

Coupling loss (two way) 2(57 + 10 + 5) = 144 db.
(wireless transmitter, wireless receiver)

Where 10 db is an allowance for field strength variations. Variations of \pm 10 db have been observed when moving only a few feet in any direction from the Radiax, facing toward vs. facing away from the Radiax with a hand-held portable unit, etc. A metal proximity loss of 5.0 db is also assumed.

Cable Attenuation loss

where $L = \text{Cable length in feet} = \frac{1.9L}{100} \text{ db}$

Power Splitter Loss (one splitter) = 3 db

Thus, the total system losses are as follows:

System Loss (one way) = 75 + $\frac{1.9L}{100}$ db

System Loss (two way) = 147 + $\frac{1.9L}{100}$ db

Note: It is anticipated by the manufacturer that the coupling loss of 57 db obtained in a non-metallic enclosure is pessimistic for steel enclosed compartments. Lower coupling losses are expected aboard ship.

Receiver Sensitivity

The receiver sensitivity is estimated from the equation for minimum detectable power, P_{min} .

$$P_{min} = kTBF$$

where $kT = 4.05 \times 10^{-21}$ (for room temperature)

B = receiver bandwidth = $2(f_m + \Delta f)$ for FM receiver

$B = 2(3.0 \text{ kHz} + 5 \text{ kHz}) = 16 \times 10^3 \text{ Hz}$

(This bandwidth is approximately equivalent to 50 kHz at -70 db)

F = receiver noise figure = 4(6 db) for field-effect transistor input.

Then $P_{min} = 4.05 \times 10^{-21} \times 16 \times 10^3 \times 4 = 2.59 \times 10^{-16}$ watts (-156 dbw)

Using $P_{min} = -156 \text{ dbw}$ (2.59×10^{-16} watts), corresponds to a voltage level at a 50-ohm receiver input resistance of

$$\begin{aligned} v_{min} &= \sqrt{P_{min}R} = \sqrt{2.59 \times 10^{-16} \times 50} \\ &= 0.11 \times 10^{-6} \text{v} (0.11 \mu\text{v}). \end{aligned}$$

The receiver sensitivity for the Motorola HT-220 transceiver is:

.35 μv maximum for 20 db of quieting (Table 2). The value of .35 μv compares well with the above approximate calculation giving .11 μv for a unity signal to noise ratio with no FM threshold improvement.

A receiver sensitivity of .35 μv across a 50-ohm receiver input is equivalent to an input power threshold P_{RT} .

$$P_{RT} = \frac{v_{in}^2}{R_{in}} = \frac{(.35 \times 10^{-6})^2}{50} = 2.45 \times 10^{-15} \text{ watts } (-146 \text{ dbw})$$

Across a 75-ohm receiver input the power is:

$$P_{RT} = \frac{v_{in}^2}{R_{in}} = \frac{(.35 \times 10^{-6})^2}{75} = 1.63 \times 10^{-15} \text{ watts } (-148 \text{ dbw})$$

The receiver input resistance is variable in the approximate range of 50 to 75 ohms depending on input tuning transformer slug position. For purposes of analysis sensitivity of -146 dbw will be used.

Expected Range

The signal power available at the receiver terminals after system losses is given as follows:

$$P_R = P_T - P_{Loss}$$

In terms of decibels of power below one watt (dbw) the above equation becomes:

(For 1 watt (+0dbw) transmitted power)

$$P_R = -(75 + \frac{1.9L}{100}) \text{ dbw, for one way wireless}$$

$$P_R = -(147 + \frac{1.9L}{100}) \text{ dbw, for two way wireless}$$

(For 5 watts (+7 dbw) transmitted power)

$$P_R = -(68 + \frac{1.9L}{100}) \text{ dbw, for one way wireless}$$

$$P_R = -(140 + \frac{1.9L}{100}) \text{ dbw, for two way wireless}$$

The above equations for received power have been plotted as a function of the cable length, L, in Figure 5.

Two receiver threshold levels are shown in Figure 5. One for $P_{RT} = -146$ dbw equivalent to 20 db of quieting and the other at $P_{RT} = -156$ dbw equivalent to about 10 db of quieting. At 100% modulation, the frequency modulation index is $\Delta f/f_m = 5 \text{ kHz}/3 \text{ kHz} = 1.67$, where Δf = maximum frequency deviation and f_m = maximum modulating frequency. The transition between narrowband and wideband FM is usually specified at a modulation index of $1/\sqrt{3} \approx 0.6$ and the FM threshold is expected to occur somewhat below 10 db. It is expected that for the condition of modulation index = 1.67, this FM receiver system will have a lowest receiver threshold of -156 dbw for a quieting in the vicinity of 10 db.

Operational Capability

The estimates for the coupling losses are the most unpredictable portion of the range analysis. The coupling loss of 57 db between transceivers and the Radiax cable is based on the manufacturer's measurements made at distances of 20 feet from the cable in non-metallic rooms and away from metal.

In the confined spaces aboard a destroyer escort 20 feet is a significant distance. For example, the approximate length and width of the fire room, the largest space in the DE-1094, is about 41 by 45 feet. Once the cable is installed, the largest and most unpredictable portion of the system loss is the location and orientation of the portable transceiver. A 10 db variation in one-way coupling loss may be expected.

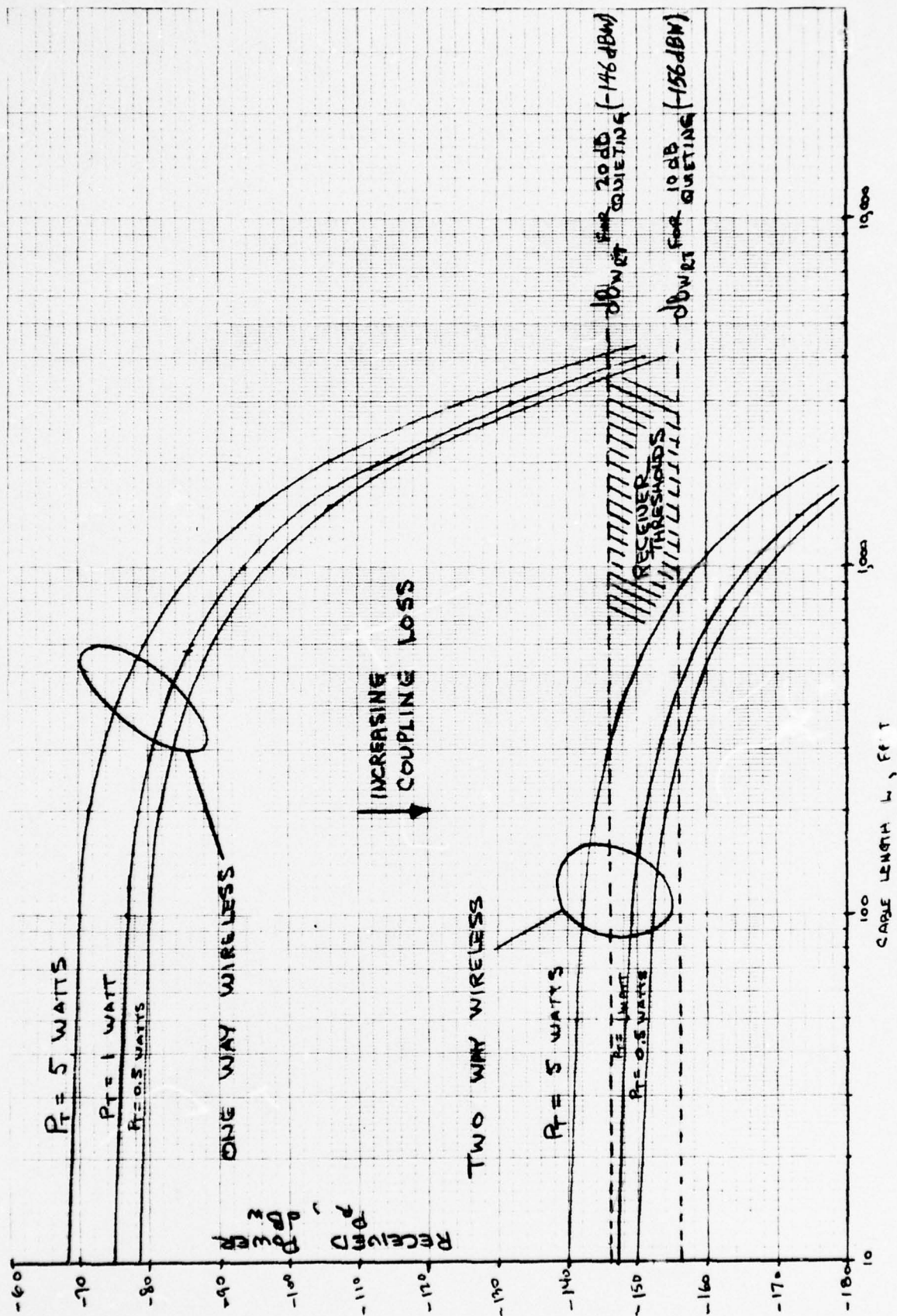


Figure 5:- Received Power versus Cable Length for Various Conditions of Transmitted Power and System Loss.

The calculations include an allowance of 10 db for antenna orientation, reflections, obstructions, etc. and a 5 db allowance for some increase in coupling loss expected when the Radiax is mounted close (within 1/2") to a metal surface. It should be noted that in the two-way wireless transmission case all the above losses are doubled in obtaining range estimates.

One-Way Wireless System

The one-way wireless system is one in which one communicating party (usually a base station) is hard wired to the Radiax cable. This removes from the system a coupling loss of $57 + 10 + 5 = 72$ db.

Under the conditions described earlier, the range estimate for 0.5, 1.0 and 5.0 watts of transmitted power can be determined from Figure 5. Thus, the expected range is:

<u>Power</u>	<u>Cable Length (ft)</u> <u>@ PRT = -146 dbw</u>	<u>Cable Length (ft)</u> <u>@ PRT = -156 dbw</u>
0.5 watts	3,580	4,100
1.0 watts	3,740	4,260
5.0 watts	4,100	4,630

For the longest cable length in any route (Route #1, aft, passage main deck to shaft alley no. 1) the distance is 572 feet. For this condition the estimated signal reserve for 20 db of threshold quieting is $146 - 86 = 60$ db for 1 watt transmitted power and 67 db for 5 watts of transmitted power.

Even with both routes tied together (572 feet + 419 feet = 991 feet), the signal reserve is still $146 - 94 = 52$ db for 1 watt and 59 db for 5 watts.

Thus, it is expected that for one-way wireless transmissions all wired compartments can be reached with a high signal reserve if a reasonable effort is made by the wireless operator to come within an unobstructed range of the Radiax cable.

Two-Way Wireless System

The two-way wireless system as the name implies uses the Radiax cable as an antenna between two or more transceivers, none of which are hard wired to the cable.

From Figure 5 the expected cable range is for 0.5, 1.0 and 5.0 watts radiated power:

<u>Power</u>	<u>Cable Length (ft)</u> <u>@ PRT = -156 dbw</u>	<u>Cable Length (ft)</u> <u>@ PRT = -146 dbw</u>
0.5 watt	316	0
1.0 watts	470	0
5.0 watts	842	316

From the calculations, it appears that success of a two-way wireless Radiax system using low transmitter power will require a high sensitivity receiver (PRT \approx -156dbw). In these calculations several assumed loss factors may be too conservative for shipboard communications and therefore, the high receiver sensitivity requirement may be somewhat alleviated. Specifically, quieting was assumed for entertainment quality reception (20 db) and no signal strength "boost" was given for two-way communication within a steel enclosure.

It is significant to note that from an operational viewpoint the need for a two-way wireless is almost always for short communicating distances. Examples are fire parties communicating with each other in adjacent compartments, or roving patrols communicating with personnel in compartments with no hardwired connections to Radiax. In extreme situations, message relay via the base station(s) is possible.

TEST PLAN ABOARD SHIP

Objectives of Test

The objectives of the shipboard wireless intercommunication system tests using Radiax cable wired through two selected routes and various compartments of a DE-1052 class destroyer escort are as follows:

1. Determine quantitatively the received signal strengths available in various locations served by the cable.

The signal strength measurements should preferably be obtained so that computations can be readily made on coupling loss, cable attenuation loss and receiver sensitivity to evaluate range and overall performance under conditions normally encountered aboard ship using the Radiax cable and transceivers.

Signal strength measurements should include received power in the major compartments especially when cable distance, transmitted power or configuration creates marginal performance.

2. Determine qualitatively the operational capability of the Radiax as an internal communications system noting such factors as: intelligibility, noise, interference between channels, interference from other sources, flexibility and ease of operation.
3. Conduct interference measurements and tests to determine the extent of interference between Radiax and other ship systems.

These measurements should include signal levels present at portable transceivers and on passive Radiax cable at the communications frequency due to pickup from ship transmitters and radars. During active operation the interference of these sources to the Radiax communications system should be noted qualitatively.

Measurements of Radiax interference to other systems should include signal strength data in various compartments and passageways that do not have Radiax cable, particularly compartments on the main deck and above.

Test Parameters, Instrumentation and Technical Procedures

Test Parameters

The quantitative measurements to be performed are mainly data on signal strength under various conditions of transmitted power, location, transceiver orientation and local configuration changes (opening and closing of doors and hatches, personnel traffic, etc.).

One of the easiest and most direct measurements of signal strength is to measure the received power directly e.g., in terms of decibels below one watt. The received power ratio in decibels relative to 1.0 watt is given by $10 \log 1.0/P_R = 10 [\log 1 - \log P_R] = -10 \log P_R$. Neglecting the negative sign (since $\log P_R$ is negative for $P_R < 1$, positive for $P_R > 1$), the received power in dbw is:

$$P_{dbw} = 10 \log P_R(\text{watts})$$

e.g. For $P_R = 2 \times 10^{-12}$ watts $P_{Rdbw} = -117$ dbw

For $P_R = 5.0$ watts $P_{Rdbw} = +7$ dbw

If the received power measurements are all made directly in dbw using calibrated transceivers there is no need for additional computations involving antenna aperture, antenna efficiency and conversion between field strengths in $\mu\text{V/m}$ to received power at the input terminals. Furthermore, the computations involving tradeoffs between transmitter power, coupling loss, cable attenuation loss, receiver sensitivity, etc. are extremely simple involving only the addition or subtraction of decibels. In fact, these results are all graphically displayed in Figure 5, where changes in coupling or other losses can be accounted for by sliding the curves up or down relative to the receiver threshold levels.

Instrumentation

A block diagram of the signal strength measuring instrumentation and calibration is given in Figure 6.

Instrument Calibration for Signal Strength Measurements

The Motorola HT-220 transceiver should be modified to measure the first stage IF amplifier limiter current by installing a connector on the case connected to the limiter output. An internal jack mounted on a circuit board inside the case for use as a test point is already connected to the first stage limiter through an RF detector providing a DC voltage proportional to the limiter current. Usually a 0 to 50 range microammeter is used for this purpose.

A signal generator set to the nominal operating frequency for the transceivers (140 MHz) should be connected directly into the receiver input through a matching transformer after disconnecting the antenna. The signal generator output voltage or attenuator setting should then be decreased until a reading in the linear portion of the limiter current characteristics well below the knee of the limiter curve is obtained. Readings should then be taken of both the limiter current and the input voltage for several points along the linear portion of the limiter characteristic. The input voltage is then converted to input power using the relationships $P_R = V_{in}^2/R_{in}$ and $dbw_R = 10 \log P_R$. The input resistance may have to be determined by measurement or from manufacturers specifications, but it is expected to be in the range of 50 to 75 Ohms.

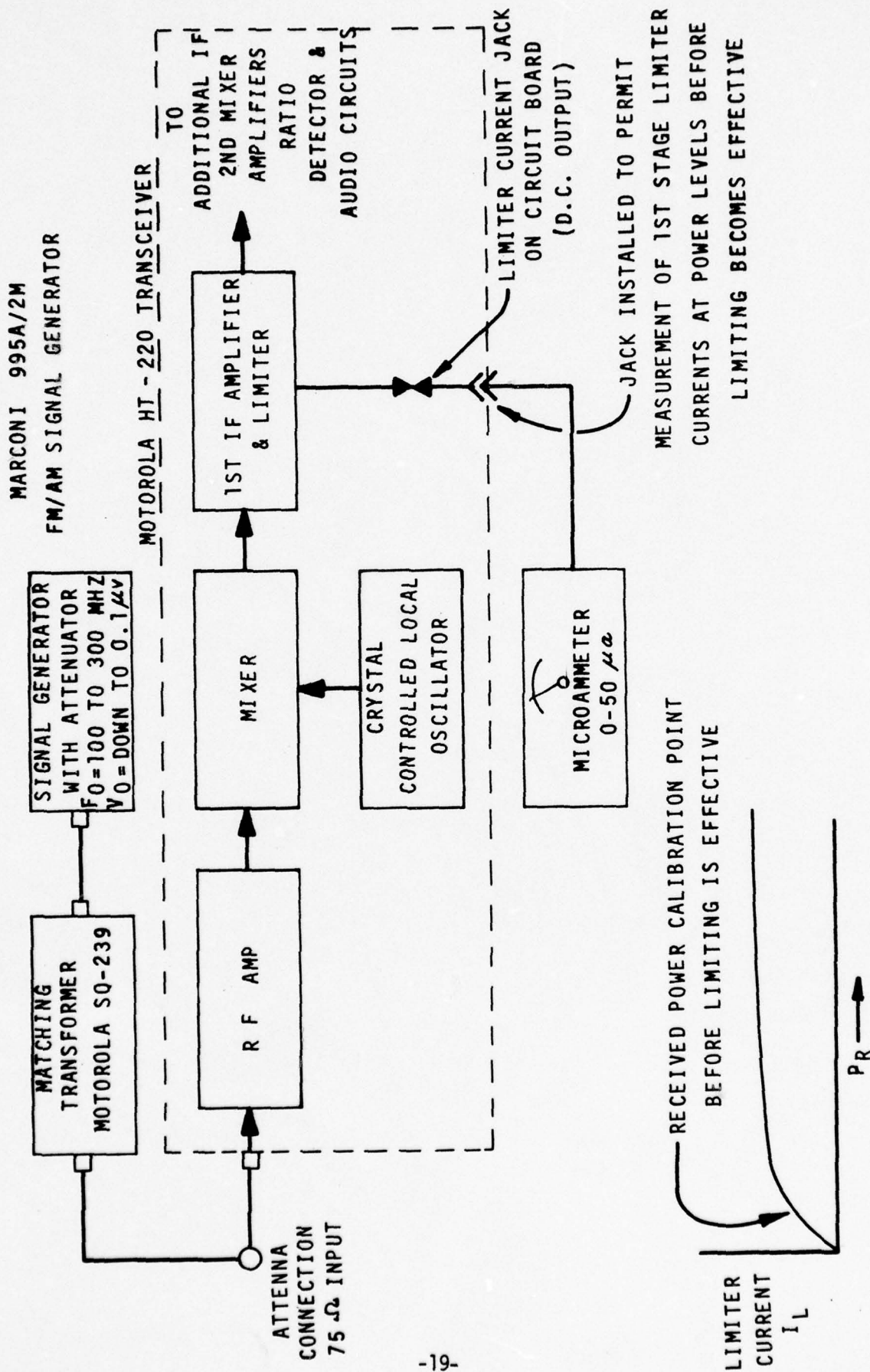


FIG 6

Since the transceivers will be used to make measurements over four frequency channels, some calibrations should be made at the frequency extremes to determine if the calibration is being influenced by frequency. The four frequencies picked for these tests are as follows:

140.025 MHz
140.050 MHz
140.075 MHz
140.125 MHz

Very little frequency influence on the calibrations is expected due to the close proximity of these frequencies.

In addition to a frequency effect on the calibration, the receivers should be checked periodically at least before and after a series of measurements with the readings averaged to obtain final signal power levels.

The microammeter reading can now be calibrated directly in terms of receiver input power with an upper limit determined on the meter where limiting occurs and readings are no longer valid. In using the transceiver to determine signal strength either the transmitter power must be adjusted by a known amount of attenuation or an attenuator inserted between the receiver antenna and the input terminals to bring the signal level within the range of the calibrated readings. Note that this measurement of receiver input power neglects the antenna gain since the measurement is made directly to the receiver input. The antenna gain is taken into account later where it is lumped together with the coupling loss. It should be noted that "antenna gain" has meaning in a reflection free space, but the compartments are far from "free space".

System Test Configuration for One-Way Wireless Measurements

The system test configuration for a one-way wireless system with a base station transceiver hard wired to the Radiax cable is shown in Figure 7.

The HT-220 transceiver is normally designed to feed a 75-Ohm load, therefore, a 75 to 50 Ohm matching transformer (Motorola vehicular antenna adapter S0-239) is needed to match the 75-Ohm transceiver output to the 50-Ohm attenuator input.

A 50-Ohm non-radiating length of cable connects the attenuator to the Radiax cable. A non-radiating section of cable is required to prevent direct pickup from the transceiver to the Radiax, thus invalidating the attenuator measurements when high attenuations (on the order of 50 db or more) are used.

The high Q coaxial choke in series with the HT-220 transceiver and Radiax cable is used to confine the RF radiation to the Radiax cable preventing RF ground currents in surrounding spaces.

Typical test instrumentation and components are as follows:

Matching Transformer	- Motorola S0-239
Power Meter	- H.P. 434A (dc to 12.4 GHz, Power range .01 - 10w)

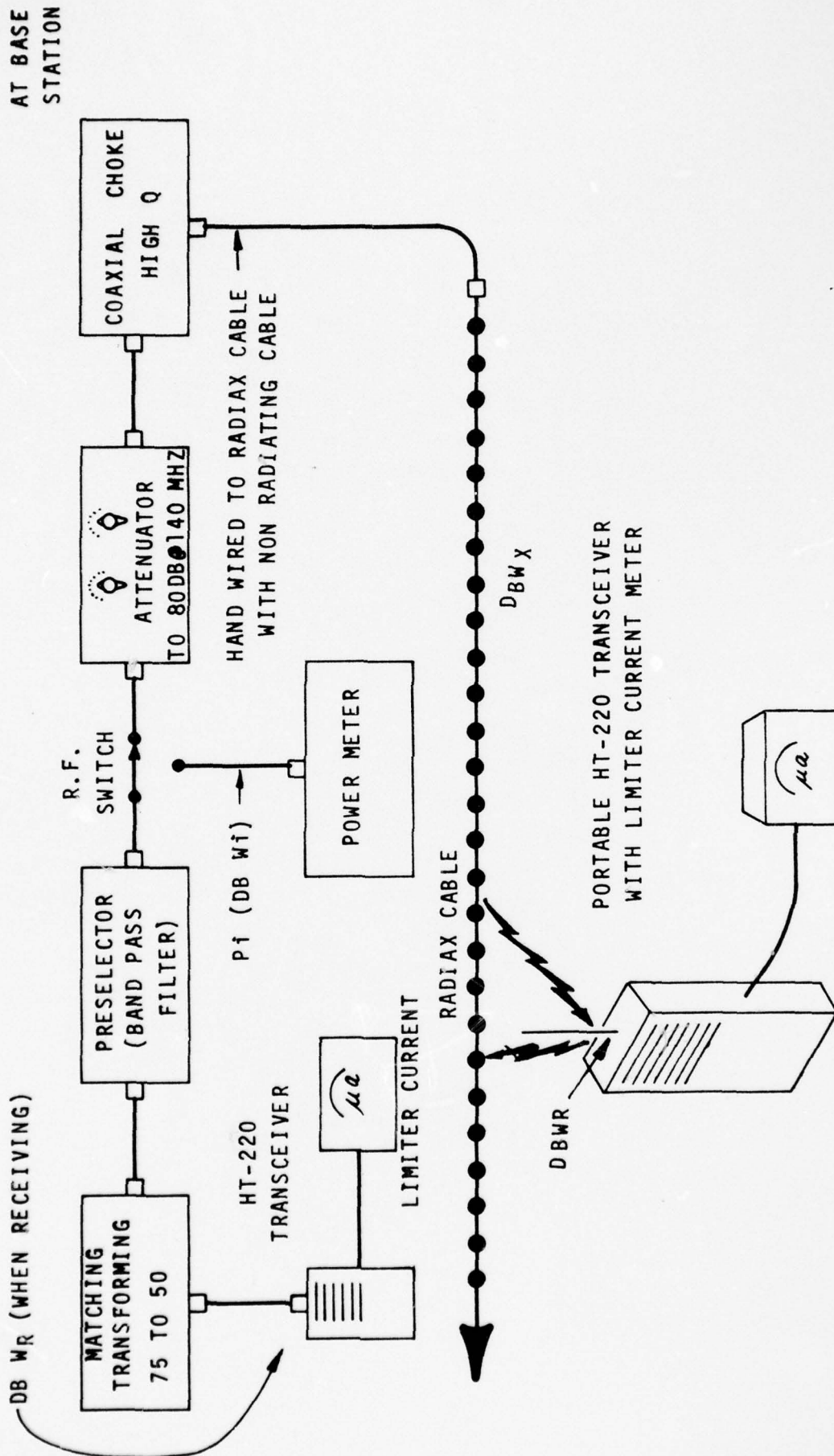


FIG 7

Attenuator	- Kay 432D (dc to 1.0 GHz, 0 to 101 db, 1 W)
Coaxial Choke	- Andrew Corporation
RF Switch	- Amphenol type 319

A preselector (bandpass filter) is required to reject shipboard radar frequencies which fall within the detection threshold of the HT-220 receiver. Characteristics of such a filter are discussed in Ref. 1, p. 23-27.

The method of performing a signal strength measurement at any remote location served by the Radiax cable is as follows:

1. Operate base station transmitter into the power meter and record base station power meter reading (dbw_i)
2. Switch transmitter into attenuator and increase attenuation until portable transceiver reports a reading within the limiter current meter calibration range. For receiving reports from the mobile unit the base station operator will require removing all or part of the attenuation. A bypass switch may be installed around the attenuator box for this purpose but care should be used to maintain proper impedance levels when paralleling coaxial cables.
3. Record readings of attenuator and portable transceiver limiter current meter.

The transmitter power dbw_x in the Radiax cable at the portable transceiver location is in terms of dbw

$$dbw_x = dbw_i - db_{atten} - db_{cable\ loss}$$

The coupling loss which includes antenna loss of the transceiver is the difference between the power at the cable dbw_x and the power dbw_R received by the calibrated transceiver, thus

$$\text{Coupling loss} = dbw_x - dbw_R$$

For example:

$$\begin{aligned} \text{Suppose } P_i &= .5 \text{ watts } (dbw_i = -3dbw) \\ db_{atten} &= 60 \text{ db} \\ L &= 400 \text{ ft. } (1.9db/100 \text{ ft.} \times 400 \text{ ft} = 7.6 \text{ db, adding } 3.0 \text{ db}^* \\ &\quad \text{loss due to power splitter} = 10.6 \text{ db cable loss}) \\ dbw_R &= -140 \text{ dbw} \end{aligned}$$

$$\text{Then } dbw_x = -3.0dbw - 60.0db - 10.6db = -73.6 \text{ dbw (at 400 ft)}$$

$$\text{Coupling loss} = -73.6dbw - (-140dbw) = 66.4 \text{ db}$$

The importance of determining coupling loss is that, once known, the system range and safety factors can be easily computed for any power level.

*In this installation a transmission path that long must have gone past the base station and hence, through a power splitter.

This method also has the advantage that antenna gain, transceiver orientation, reflections within the compartment, proximity effect of Radiax to metal surfaces, etc. is all lumped together in one factor called the coupling loss.

Estimates of cable losses from any one compartment to another have been determined in Appendix 1. Thus, coupling loss can be readily computed and recorded together with signal strength readings for any position along the Radiax cable. Power splitter loss is not included in the Appendix 1 tables and must be separately included if the cable path passes through the splitter.

Determination of Coupling Loss in Each Direction

During the one-way wireless signal strength measurements it should be determined whether the coupling loss is reciprocal, i.e., is the coupling loss identical from Radiax to the portable antenna when receiving and from the portable antenna to Radiax when transmitting to the cable?

These measurements are made as follows:

1. Measure the transmitted power dbw_T into the antenna of the portable transceiver by removing the antenna and coupling the transmitter output to the power meter through a 75 to 50-ohm coupling transformer. Correct for any transformer losses.
2. Measure the power received at the base station from the portable transceiver using a limiter current calibrated HT-220 transceiver coupled directly to the Radiax cable through the matching transformer, preselector and coaxial choke. In other words, the attenuator is set to zero or whatever attenuation is needed to obtain a reading within the limiter current calibration range.
3. Enter the data for both to and from measurements in the table of Figure 8 and compute coupling loss each way taking into account cable loss, power splitter loss, etc.

Figure 8 includes provision for a coupling loss measurement to and from the Radiax cable. In the "portable" column would be recorded the received power and computed coupling loss from Radiax to portable. In the base "station or portable" column would be recorded the base station received power and the coupling loss from the portable antenna to the Radiax cable.

As previously noted, if the receivers are properly calibrated such that a known input power to the receiver terminals gives a reading within the linear portion of the limiter the antenna loss or gain becomes a part of the coupling loss measurement with no loss of accuracy in determining range or signal margins.

The signal strength measurement method described above has the additional advantage of simplicity, ease of implementation and interpretation because:

All the instrumentation with the exception of the portable transceiver and attached meter is contained at the base station where changes in attenuation and all data recording is done.

System Test Configuration for Two-Way Wireless Measurements

For two-way wireless measurements where two portable wireless units communicate with each other, the following measurements should be taken:

1. Measure the transmitted power dbm_T into the antenna of each portable transceiver to be used for the two-way wireless tests by removing the antennas and coupling the transmitter output to the power meter through a 75 to 50-Ohm coupling transformer. Correct for any transformer losses and repeat these measurement periodically.
2. Measure received power dbm_R at each mobile location using the calibrated transceiver limiter current method. Note that these mobile locations must be precisely in the same position, same antenna orientation and same environmental conditions as those encountered during the one-way wireless tests.
3. Using the computed coupling losses in both directions from the one-way wireless measurements, compute the total losses, range and signal margins for the selected locations.

Note from the above measurements that the total path coupling losses can be computed directly and then compared to the sum of the previously computed coupling losses in either direction.

System Measurement Data and Computation Sheet with Case Examples

A sample form for the taking of signal strength data with a computations format has been prepared (Fig. 8).

It is expected that these forms can be filled out at the base stations with the mobile parties reporting the data.

Three sample cases have been prepared, a one-way wireless test (Fig. 9), a two-way wireless test (Fig. 10), and an interference test (Fig. 11).

One-way Measurement Example

The one-way measurement example is for a signal level measurement between the engine control station (hard wired) and the lowest level of the fire room of the forward route.

For purposes of analysis, all the data indicated in the sample sheet should be entered.

Cable length between parties is found from Appendix 1 and can be entered later during the analysis phase. At the base station, the power into the Radiac is obtained from a meter reading and the attenuator box setting is determined after a limiter current reading within the portable transceiver calibration range is determined.

The computations are then performed according to the instructions in the measurement and computation sheet.

Two-Way Measurement Example

The two-way measurement example is for a signal level measurement between two portable transceivers, one located in the F.D. blower room at the same location as the one-way test example and the other located in the fire room. Previous one-way measurements have established a coupling loss of 64 db in the F.D. blower room, and 71 db in the fire room. For generality, the power into each portable antenna (obtained by measurement) is different (-3.0 dbw and 0 dbw).

The total path loss is a cable attenuation + coupling loss of 1.0 db + 64 db + 71 db = 136 db. Thus, the received power at the fire room from the F.D. blower room is -3.0 dbw - 136 db = - 136 dbw and the received power at the F.D. blower room from the fire room is 0 dbw - 136 db = - 136 dbw.

Interference Test Example

An example of an interference signal level measurement is given in Figure 11 for a portable receiver on the first deck in passage 1-83-2-L. Other interference tests at the base station using the Radiax route can be performed by setting the attenuator box to zero and using a limiter current calibrated transceiver to perform a signal level measurement. The power meter is not sensitive enough for this purpose.

Date		Observer		Recorder	
SYSTEM MEASUREMENT DATA & COMPUTATION SHEET					
Test No.	One-way	Two-way	Interference	Base Station or Portable #	Portable #
Route (fwd or aft)					
Compartments -- Name & No.					
Location within compartments					
Closest Distance to Radiax, ft.					
Transceiver Orientation for best reception (Std. orientation is antenna whip vertical at normal head height.)					
Local Configuration & Environment					
Transmitter Frequency, MHz					
Signal Quality, Interference, etc.					
Cable Length between parties, ft. & attenuation $dbw_{cable\ loss}$					
Transceiver Pwr to Radiax, dbw_i Transceiver Pwr to Antenna, dbw_t					
Attenuator Box Setting, db dbw_{atten}				Std.	Best
Limiter Current, μA Received Pwr, dbw_R					
Radiax Cable Pwr, dbw_x $dbw_x = dbw_i - dbw_{atten} - db_{cable\ loss}$					
Coupling Loss, db $dbw_x - dbw_R$					
Receiver Sensitivity dbw_{RT} threshold,					
Range, ft. (from Fig. 5) or Signal Margin = $dbw_{atten} + dbw_R - dbw_{RT}$ Above Thresholds					

Figure 8:- System Measurement Data and Computation Sheet
Sample Form

SYSTEM MEASUREMENT DATA & COMPUTATION SHEET					
Test No.	One-way X	Two-way	Interference	Base Station or Portable	Portable
Route (fwd or aft)				Fwd	Fwd
Compartments -- Name & No.				Engine Control 2-95-0-E	Fire Room 5-79-0-E
Location within compartments				----	Lowest level, midway between boilers, 23' from stbd side
Closest Distance to Radiax, ft.				Hard wired (base station)	≈ 7'
Transceiver Orientation				-----	Antenna horizontal facing port side
Local Configuration & Environment				All doors & hatches closed	All doors and hatches closed; man on station (above catwalk)
Transmitter Frequency, MHz				140.050	
Signal Quality, Interference, etc.				Good signal quality, understanding excellent; occasional noise interference	
Cable Length between parties, ft. & attenuation dbw _{cable loss}				107', 2.0db + 3.0db(pwr split)=5.0db	
Transceiver Pwr to Radiax, dbw _i				0.5W(-3.0dbw)	---
Transceiver Pwr to Antenna, dbw _t				---	---
Attenuator Box Setting, db dbw _{atten}				70 db	---
Limiter Current, μA				20 μA	20 μA
Received Pwr, dbw _R				-142 dbw	- 142 dbw
Radiax Cable Pwr, dbw _x dbw _x = dbw _i - dbw _{atten} - db _{cable loss}				---	- 78 dbw _x
Coupling Loss, db dbw _x - dbw _R				64 db	64 db
Receiver Sensitivity dbw _{RT} threshold,				-146 dbw for 20 db quieting	-146 dbw For 20 db quieting
Range, ft. (from Fig. 5) or Signal Margin= dbw _{atten} +dbw _R -dbw _{RT} 1. Above Thresholds				70-142-(-146)=74 db above 20 db quieting threshold	

Note 1. For two-way test dbw_{atten} = 0.

Figure 9: One-way Wireless Test Sample Data and Calculations

SYSTEM MEASUREMENT DATA & COMPUTATION SHEET					
Test No.	One-way	Two-way X	Interference	Base Station or Portable	Portable
Route (fwd or aft)				Fwd	Fwd
Compartments -- Name & No.				F.D. Blower Room 1-79-0-E	Fire Room 5-79-0-E
Location within compartments				At entrance to passage 1-83-2-L	Lowest level; midway between boilers; 23' from stbd side
Closest Distance to Radiax, ft.				2'	≈ 7'
Transceiver Orientation				Antenna vertical; operator facing F.D. blower room	Antenna horizontal; facing port side
Local Configuration & Environment				door to passage 1-54-2-6 closed; door to engine RM closed	all doors and hatches closed; man on station (above catwalk)
Transmitter Frequency, MHz				140.050	
Signal Quality, Interference, etc.				Good signal quality, good understanding, but very susceptible to antenna orienta- tion; ±2 ft. causes fading	
Cable Length between parties, ft. & attenuation dbw _{cable loss}				43', 0.8 db (assume 1.0 db)	
Transceiver Pwr to Radiax, dbw _i				----	----
Transceiver Pwr to Antenna, dbw _t				0.5w (-3.0dbw)	1.0w (0 dbw)
Attenuator Box Setting, db dbw _{atten}				Note 1.----	Note 1.----
Limiter Current, μA				40 μA	40 μA
Received Pwr, dbw _R				-136 dbw	-139 dbw
Radiax Cable Pwr, dbw _x dbw _x = dbw _i - dbw _{atten} - db _{cable loss}				----	----
Coupling Loss, db dbw _x - dbw _R				71 db	64 db
Receiver Sensitivity dbw _{RT} threshold,				-146 dbw for 20db quieting	-146 dbw for 20db quieting
Range, ft. (from Fig. 5) or Signal Margin = dbw _{atten} + dbw _R - dbw _{RT} 1. Above Thresholds				+10db above 20db quieting threshold	+7db above 20db quieting threshold


Note 1. For two-way test dbw_{atten} = 0

Figure 10: Two-way Wireless Test Sample Data and Calculations

SYSTEM MEASUREMENT DATA & COMPUTATION SHEET					
Test No.	One-way	Two-way	Interference X	Base Station or Portable	Portable
Route (fwd or aft)					Fwd
Compartments -- Name & No.					Passage 1-83-2-L
Location within compartments					At station 95
Closest Distance to Radiax, ft.					$\approx 2'$
Transceiver Orientation					Antenna vertical
Local Configuration & Environment					door to port passage 1-54-2-L open
Transmitter Frequency, MHz				-----	
Signal Quality, Interference, etc.				Low level varying freq. tone observed at rep. rate of about 1 Hz	
Cable Length between parties, ft. & attenuation $dbw_{cable\ loss}$				-----	
Transceiver Pwr to Radiax, dbw_i					---
Transceiver Pwr to Antenna, dbw_t					----
Attenuator Box Setting, db dbw_{atten}					----
Limiter Current, μA Received Pwr, dbw_R					30 A to >50 A(saturation) -139dbw >-130dbw
Radiax Cable Pwr, dbw_x $dbw_x = dbw_i - dbw_{atten} - db_{cable\ loss}$					----
Coupling Loss, db $dbw_x - dbw_R$					----
Receiver Sensitivity dbw_{RT} threshold,					----
Range, ft. (from Fig. 5) or Signal Margin= $dbw_{atten} + dbw_R - dbw_{RT}$ Above Thresholds				Signal occasionally above receiver 20db threshold by -146-(-139)=+7db to >+16db	

Figure 11. Test of Interference to Radiax Operation
Sample Data for Portable Transceiver

Test Locations and Procedures

One-way Wireless Tests:- The test locations for obtaining signal strength and interference measurements are given in Tables 3 and 4 for the forward and aft Radiax cable routes and are also indicated by  in the cable installation plan (Appendix 3 and 4). These are considered the minimum number of test locations.

In performing the signal measurements, operators of portable transceivers should get data for a standard whip vertical position and for a "best" orientation, recording the best direction as well as signal strength. The location of the operator should be marked on the deck so that subsequent measurements can be carried out from the same location.

Hatches, emergency escape trunks, etc. should all be closed during these tests, maintaining condition Zebra (watertight integrity) unless required to be open for some special tests.

Table 3: Forward Route One-way Wireless Test Locations
(Base Station at Engine Control Room)

Compartment and Number	Location within Compartment	Compartment Doors		Test Number
		open	closed	
Damage control central 2-54-Q-Q (2)	Center	X		1F-1
Oper. Dept. Office (1) 2-64-2-Q	Center		X	1F-2
Test laboratory (1) 2-77-1-Q	Center		X	1F-3
General Workshop 3-54-0-Q	Center		X	1F-4
Electrical Control (2) 3-59-0-C	Center, between switchboards		X	1F-5
Aux. Mach. Rm. No. 1 (2) 3-67-0-E	Upper level at fwd ladder		X	1F-6
	Upper level extreme port side		X	1F-7
	Lowest level at ladder		X	1F-8
Fire Room (2) 5-79-0-E	Lowest level between boilers		X	1F-9
	Fire room control station		X	1F-10
	Control Station level at up ladder		X	1F-11
F.D. blower room No. 1 1-79-0-E	Center		X	1F-12
Passage 1-83-2-L	Center of passage	X		1F-13
Passage (1) 1-54-2-L	At frame 79		X	1F-14
			X	1F-15
F.D. blower room no. 2 (1) 1-90-0-E	Center		X	1F-16
Engine room (2) 5-95-0-E	Upper level catwalk opposite LP turbine		X	1F-17
F.D. Storeroom 3-107-1-A	Upper level at ladder		X	1F-18
Shaft Alley #1 (2) 4-107-0-0	At bottom of ladder	X		1F-19

- (1) Test for radiation levels in unwired compartments or passages
(2) Locations for two-way wireless tests prior to and after Radfax installation

Table 4: Aft Route One-way Wireless Test Locations
(Base Station at Repair III)

Compartment and Number	Location within Compartment	Compartment Doors		Test Number
		open	closed	
Passage (main deck) 1-121-0-L (2)	Opposite post office		X	1A-1
Passage (main deck) 1-95-4-L (1)	Fwd of bulkhead 107		X	1A-2
Aux. Radio Room 1-110-2-0 (1)	Center		X	1A-3
Passage (2nd deck) 2-121-0-L	Opposite scullery	X		1A-4
CPO Quarters 2-127-0-L	Center		X	1A-5
Galley 2-107-0-L	Center	X		1A-6
Crew's Mess 2-107-0-L (2)	At down ladder	X		1A-7
Passage (2nd deck) 2-132-0-L	Midway		X	1A-8
Laundry 2-136-0-Q	Center		X	1A-9
Torpedo Room 2-147-0-M (2)	Center between Sta 147 & 158; also, near stern		X X	1A-10 1A-11
VDS Mach. Room 2-158-0-E	Near door to torpedo room		X	1A-12
Passage 3-155-1-L	Bottom of ladder	X		1A-13
Steering Room 3-155-0-E (2)	At control station fwd	X		1A-14
Passage 3-155-0-E	Center	X		1A-15
Passage 3-147-01-L	Center		X	1A-16
Aux. Mach. Rm. #2 SWBD Area 3-133-01-E (2)	Center		X	1A-17
Aux. Mach. Rm. #2 Diesel Area 3-132-01-E	At fwd end		X	1A-18
Crew Living Space 3-121-0-L	Center Aft-stbd corner	X X		1A-19 1A-20
Shaft Alley No. 2 5-121-0-Q	Bottom of ladder	X		1A-21
Passage 3-110-2-L	At down ladder		X	1A-22

(1) Test for radiation levels in unwired compartments or passages.

(2) Locations for two-way wireless tests prior to and after Radiax installation.

Table 4 (cont'd)

Compartment and Number	Location within Compartment	Compartment Doors		Test Number
		open	closed	
Passage 5-111-2-L	Midway		X	1A-23
Shaft Alley No. 1 4-107-0-Q (2)	At bottom of ladder	X		1A-24

Two-way Wireless Tests:- Two-way wireless measurements should be made between the selected locations given in Tables 5 and 6 where coupling loss measurements between the cable and a portable transceiver will have been determined by one-way wireless tests between base stations and portable transceivers.

For the pre-Radiac two-way measurements (Appendix 2) Tables 5 and 6 define the compartment locations while Tables 3 and 4 give additional details on location within compartments. The pre-Radiac tests should be recorded on the form of Figure 9, entering all the pertinent information except that from these tests only the total two-way coupling loss can be determined.

Table 5:- Two-way Wireless Test Locations
Forward Route

Transceiver No. 1 Compartment and Number	Transceiver No. 2 Compartment and Number	Test Number
Damage Control Central 2-54-0-Q	Electrical Central 3-59-0-C	2F-1
Damage Control Central 2-54-0-Q	Aux.Mach.Rm.No. 1 3-67-0-E	2F-2
Damage Control Central 2-54-0-Q	Fire Rm.Control Station 5-79-0-E	2F-3
Damage Control Central 2-54-0-Q	Engine Rm.Control Station 5-95-0-E	2F-4
Damage Control Central 2-54-0-Q	Shaft Alley No. 1 4-107-0-0	2F-5
Engine Rm.Control Sta. 5-95-0-E	Fire Rm.Control Station 5-79-0-E	2F-6
Engine Rm.Control Sta. 5-95-0-E	Electrical Central 3-59-0-C	2F-7
Engine Rm.Control Sta. 5-95-0-E	Aux.Mach.Rm. No. 1 3-67-0-E	2F-8
Engine Rm.Control Sta. 5-95-0-E	Shaft Alley No. 1 4-107-0-0	2F-9
Engine Rm.Control Sta. 5-95-0-E	Repair III 2-141-2-A	2F-10

NOTE: For exact locations within compartments see Table 3, note (2).

Table 6:- Two-way Wireless Test Locations
(Aft Route)

Transceiver No. 1 Compartment and Number	Transceiver No. 2 Compartment and Number	Test Number
Repair III 2-141-2-A	Passage (main deck) 7-121-0-L	2A-1
Repair III 2-141-2-A	Torpedo Room 2-147-0-M	2A-2
Repair III 2-141-2-A	Aux.Mach. Room No. 2 3-132-01-E	2A-3
Repair III 2-141-2-A	Shaft Alley No. 1 5-121-0-Q	2A-4
Repair III 2-141-2-A	Steering Room 3-155-0-E	2A-5
Repair III 2-141-2-A	Crew's Mess 2-107-0-L	2A-6
Aux.Mach.Rm. No. 2 3-132-01-E	Shaft Alley No. 1 4-107-0-Q	2A-7
Aux.Mach.Rm. No. 2 3-132-01-E	Steering Room 3-155-0-E	2A-8

NOTE: For exact locations within compartments see Table 3, note (2).

Interference Measurements:- Interference measurements should be made to establish the signals from Radiax in those compartments not wired with Radiax. Both quantitative and qualitative measurements can be obtained using the standard data sheets with measurement data supplied from calibrated transceivers. Generally, the need for such measurements below the main deck is unnecessary since the object of the communications system is to radiate energy wherever possible. On the main deck and above it is necessary to both contain the emissions within the ship and keep them out of certain compartments (such as the communications room). Tables 3 and 4 (note 1) indicate those compartments not wired with Radiax that should be tested for signal level when the Radiax system is in use.

Interference of other systems to Radiax whether portable units or at base stations must be determined by isolating interfering sources one at a time. Thus, radars and communications systems that have been analyzed to be potential sources of interference should be turned on and off while measurements are taken in various locations.

The RF interference induced by the two-way units into ships cabling is expected to be virtually nonexistent since all of the ships cabling is enclosed by a heavy metal shield (armor). As previously discussed, the large frequency difference between dc or 60 Hz control circuits and 140 MHz in the wireless communications system essentially eliminates the Radiax interference problem to control circuits. For control circuits located within compartments covered

by Radiax or in base stations, the RF signal pickup should be in the very low millivolt range at worst, well below other types of pickup from 60 Hz radar, sonar and high powered communication systems.

An FM transceiver system is ideally suited in this application because of the extremely effective suppression of AM-type noise which is very prevalent everywhere in the ship due to operation of switches, motors, relays, etc. In addition, there is a noise quieting gain common to FM systems once the signal is above the detection threshold. This quieting gain increases the output signal-to-noise ratio relative to an AM system by an estimated 10 db after the input signal-to-noise ratio exceeds about 10 db for this almost narrow band FM system.

The interference of Radiax communications using the HT-220 transceivers to other ship communications systems aboard the DE-1052 class destroyer escort was investigated and reported in reference 1. It was determined in that study that the HT-220 could interfere with the receiver portion of the PRC-73 and with the URR-27 receiver. In addition, it was found that a pre-selector would be needed to be hard wired to the Radiax cable to reduce the transceiver spurious responses to high-level, out-of-band emissions from the SPS-37 and SPS-40 radars.

The table below is reproduced from reference 1, showing that harmonic frequencies of the HT-220 up to $7F_0$ should be measured. It is recommended that field intensity measurements be made to obtain the data for Table 7, using an Empire field strength meter in the communications room and aux. radio room.

Ref. 1. Mattox, W.J., "Electromagnetic Compatibility Study of a Wireless Inter-communication System for DE-1052 Class," ITT Research Institute, Electromagnetic Compatibility Analysis Center, Annapolis, Md., July 1974

Table 7.

EMISSION DATA RECORDING SHEET

Equipment Under Test _____ Date _____

S/N _____ Test Personnel _____

Antennas _____

Test Location _____

Measurement Equipment _____

Position on Radiax _____

Frequency MHz	Position From Vertical Horizontal	Meter Reading dB/uV	Attn Factor dB	Ant Factor dB	Other Factors dB	Corrected Level dB/uV/M	Notes
___ (F ₀)							
___ (4/3 F ₀)							
___ (5/3 F ₀)							
___ (2 F ₀)							
___ (7/3 F ₀)							
___ (8/3 F ₀)							
___ (3 F ₀)							
___ (10/3 F ₀)							
___ (11/3 F ₀)							
___ (4 F ₀)							
___ (13/3 F ₀)							
___ (14/3 F ₀)							
___ (5 F ₀)							
___ (16/3 F ₀)							
___ (17/3 F ₀)							
___ (6 F ₀)							
___ (19/3 F ₀)							
___ (20/3 F ₀)							
___ (7 F ₀)							

Ref. 1. Mattox, W.J., "Electromagnetic Compatibility Study of a Wireless Inter-communication System for DE-1052 Class," ITT Research Institute, Electromagnetic Compatibility Analysis Center, Annapolis, Md., July 1974

A P P E N D I X 1

INTERCOMPARTMENT CABLE LENGTHS (feet)
(Center to Center of Each Compartment)

and

CABLE ATTENUATION LOSSES (db)

For Two Radiac Cable Routes

On DE-1094 Destroyer Escort

Note: () = Loss in db
computed as
1.9 db/100 ft.

-38-

ROUTE #2 (Fwd)

Note: ()=Loss in db
computed as
1.9db/100 ft.

	Damage Control Central	General Workshop 3-54-0-Q	Crew Living Space 3-59-2-L	Electrical Central	Aux. Mach. Room #1	Fire Room	F.D. Blower Room #1 1-79-0-E	Passage 1-83-2-L	Comm. Officer Sr. 1-95-2-L	Engine Control 2-95-0-E	Repair Parts Storeroom 3-107-1-A	Shaft Alley No. 1
Damage Control Central	--											
General Workshop 3-54-0-Q	22 (0.4)	--										
Crew Living Space 3-59-2-L	44 (0.8)	22 (0.4)	--									
Electrical Central	68 (1.3)	46 (0.9)	24 (0.5)	--								
Aux. Mach. Room #1	124 (2.4)	102 (1.9)	80 (1.5)	56 (1.1)	--							
Fire Room	232 (4.4)	210 (4.0)	188 (3.6)	164 (3.1)	108 (2.1)	--						
F.D. Blower Room #1	275 (5.3)	253 (4.8)	231 (4.4)	207 (3.9)	151 (2.9)	43 (0.8)	--					
Passage	286 (5.4)	264 (5.0)	242 (4.6)	218 (4.1)	162 (3.1)	54 (1.0)	11 (0.2)	--				
1-83-2-L	319 (6.1)	297 (5.6)	275 (5.2)	251 (4.8)	195 (3.7)	87 (1.7)	44 (0.8)	33 (0.6)				
Comm. Officer Sr.	339 (6.4)	317 (6.0)	295 (5.6)	271 (5.2)	215 (4.1)	107 (2.0)	64 (1.2)	53 (1.0)	--			
Engine Control	392 (7.5)	370 (7.0)	348 (6.6)	324 (6.2)	268 (5.1)	160 (3.0)	117 (2.2)	106 (2.0)	73 (1.4)	53 (1.0)	--	
Repair Parts Storeroom 3-107-1-A	419 (8.0)	397 (7.5)	375 (7.1)	351 (6.7)	295 (5.6)	187 (3.6)	144 (2.7)	133 (2.5)	100 (1.9)	80 (1.5)	27 (0.5)	--
Shaft Alley No. 1												

A P P E N D I X 2

Shipboard Communications Measurements Prior to Radiax Cable Installation

Several past experiments with portable FM low power transceivers aboard Navy ships by NAVSEC and NSRDC personnel have established that it is possible to communicate across several closed steel compartments. Apparently, the electromagnetic radiation follows ships cables, piping, ducting and other penetrations to provide some leakage radiation between steel compartments. The unpredictable nature of this leakage radiation, limited coverage and great susceptibility to changes in local environment makes it impractical to rely totally on such a low reliability transmission path. The installation of Radiax cable will significantly increase the radiation throughout the wired compartments, in effect greatly augmenting the normal leakage transmission paths.

To evaluate the contribution of the Radiax cable in providing radiation within compartments, it is necessary to establish some baseline of performance without Radiax since both normal leakage radiation together with Radiax radiation will exist once the Radiax is installed. Thereafter, separation of the two components is impossible. Thus, it is necessary to establish received signal strengths across several compartments prior to Radiax installation.

The signal strength measurement method using calibrated transceivers discussed in the test plan should be used (Fig. 6) using the same procedures as discussed under the section "System Test Configuration for Two-way Wireless Measurements". The locations for these pre-Radiax tests are shown in Tables 5 and 6 and subsequent tests (both one-way and two-way) must be performed in the identical locations duplicating all conditions as closely as possible.

Hard Wiring Two Base Stations to Radiax Cable

Under the present plan only one transceiver is hard wired to the Radiax cable at a base station. Two transceivers cannot be hard wired to the same Radiax cable (say, at the engineering control station and damage control central) because the transmitter output power will destroy the receiver input circuit at the other end. In other words, with several hundred feet of Radiax cable, the cable losses are insufficient to absorb the transmitted power, leaving an excessive amount of power to be dissipated at the receiver input. For example, with no line loss, the voltage at the receiver input for 1 watt of transmitted power across 50 ohms would be from $P = v^2/R$; $v = \sqrt{1 \times 50} = 7.1$ volts RMS.

The Motorola HT-220 transceivers have several protection features which protect the receiver input from excessive input voltages through radiation pickup when transmitting. The RF amplifier input has a diode limiter, during transmission the supply voltage to the receiver RF, mixer and IF stages are

removed and the common antenna is switched from the receiver input to transmitter output. These features protect against radiation into the sensitive receiver input stage.

For a hard wired transceiver these protection features would be of no value since the receiver would be coupled to the Radiax with receiver power circuits active and sufficient power coming through the Radiax to burn out the diode limiter. (Information supplied by manufacturer.)

If a scheme for employing two hard wired transceivers on a common Radiax cable is desired, then the receivers should be modified to provide greater protection in the receive mode.

During the tests where the two cable routes are tied together in the shaft alley, care must be taken that one of the hard wired base stations is removed from the Radiax cable, otherwise damage to both transceivers is likely.

APPENDIX 3

Aft Radiax Route

Base Station at Repair No. 3

SIGNIFICANCE OF SYMBOLS



DECK PENETRATION OF STUFFING TUBE



BULKHEAD PENETRATION OR STUFFING TUBE



MULTICABLE TRANSIT FRAME



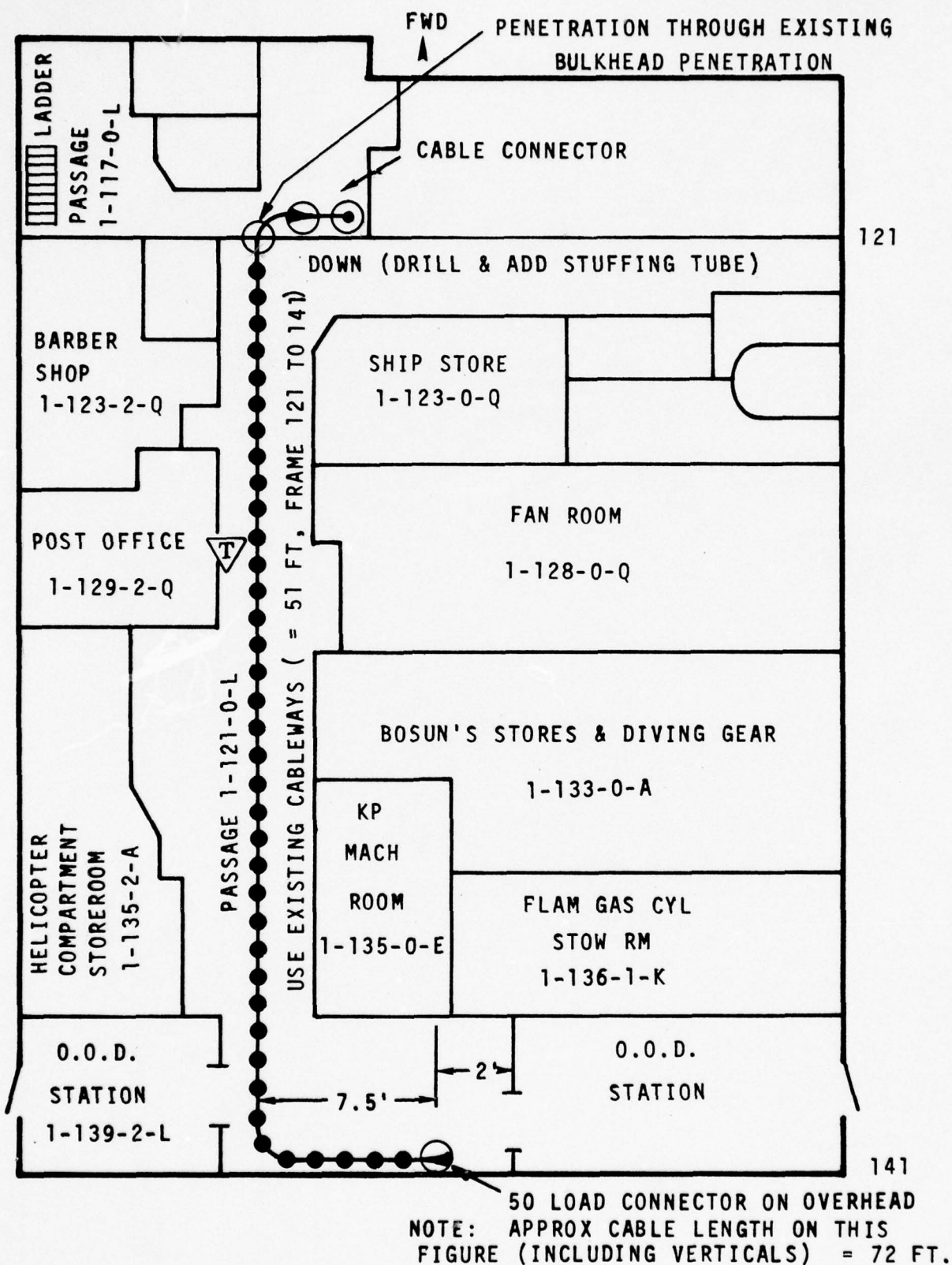
TRANSCIEVER LOCATION DURING TEST



CONNECTOR

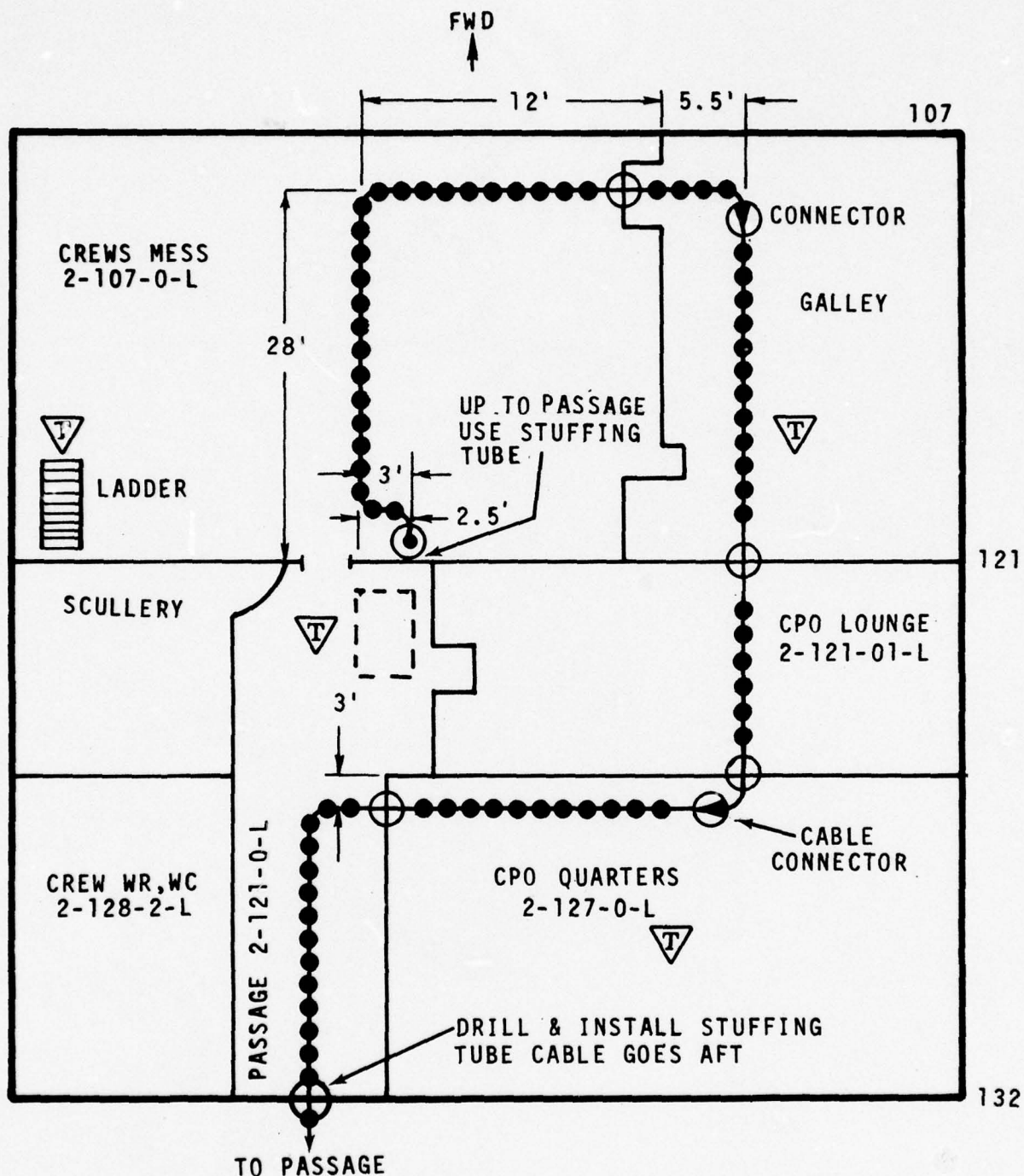
FEMALE

MALE



NOTE: DURING PORTIONS OF THE TEST THE ENTIRE PASSAGEWAY LENGTH OF RADIAX WILL BE DISCONNECTED AT THE CONNECTOR SYSTEM AND TERMINATED WITH A 50 OHM LOAD.

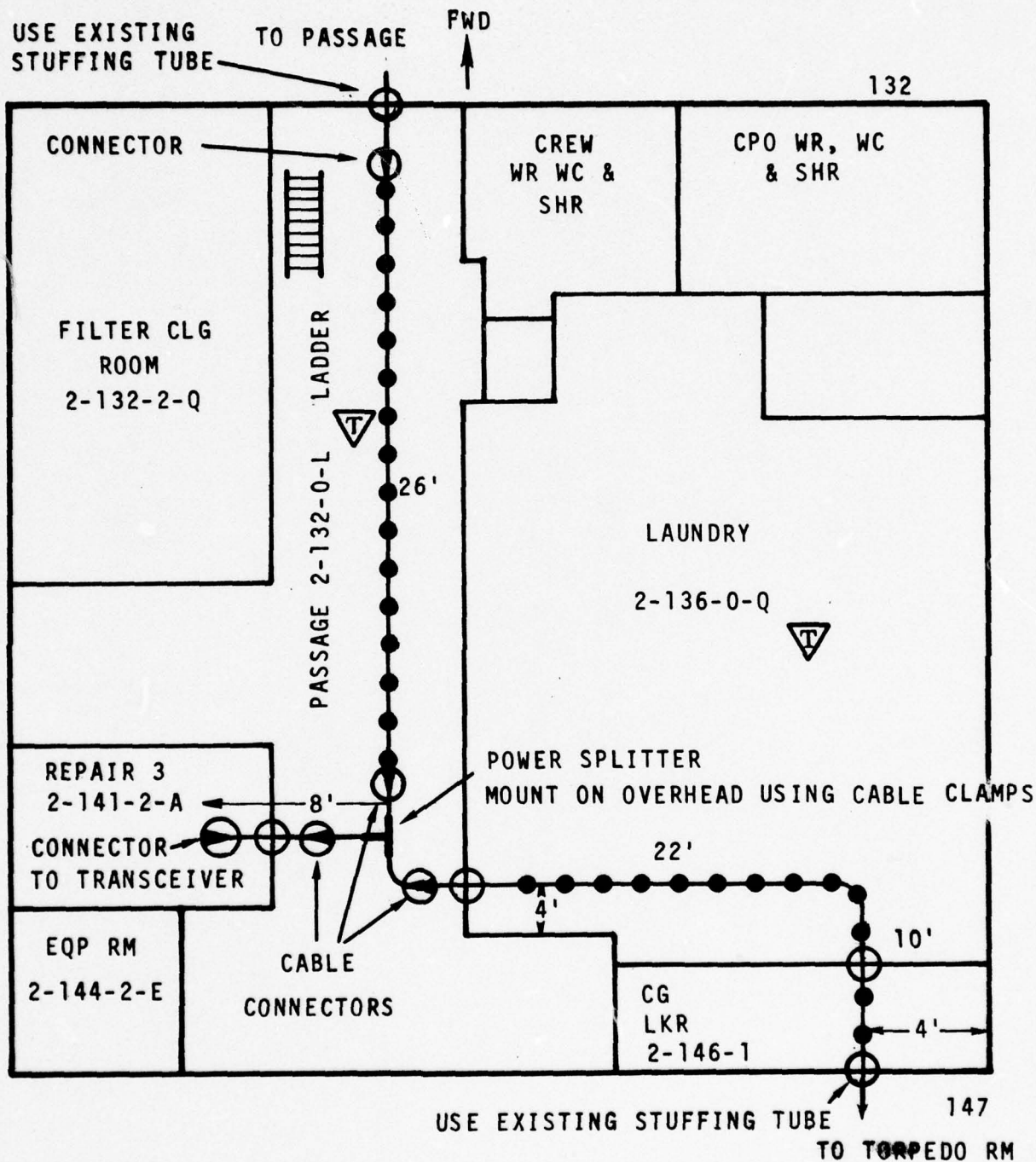
FIG 3-1



NOTE: USE EXISTING CABLEWAYS AND BULKHEAD PENETRATIONS THROUGHOUT

NOTE: APPROX CABLE LENGTH ON THIS FIG = 125

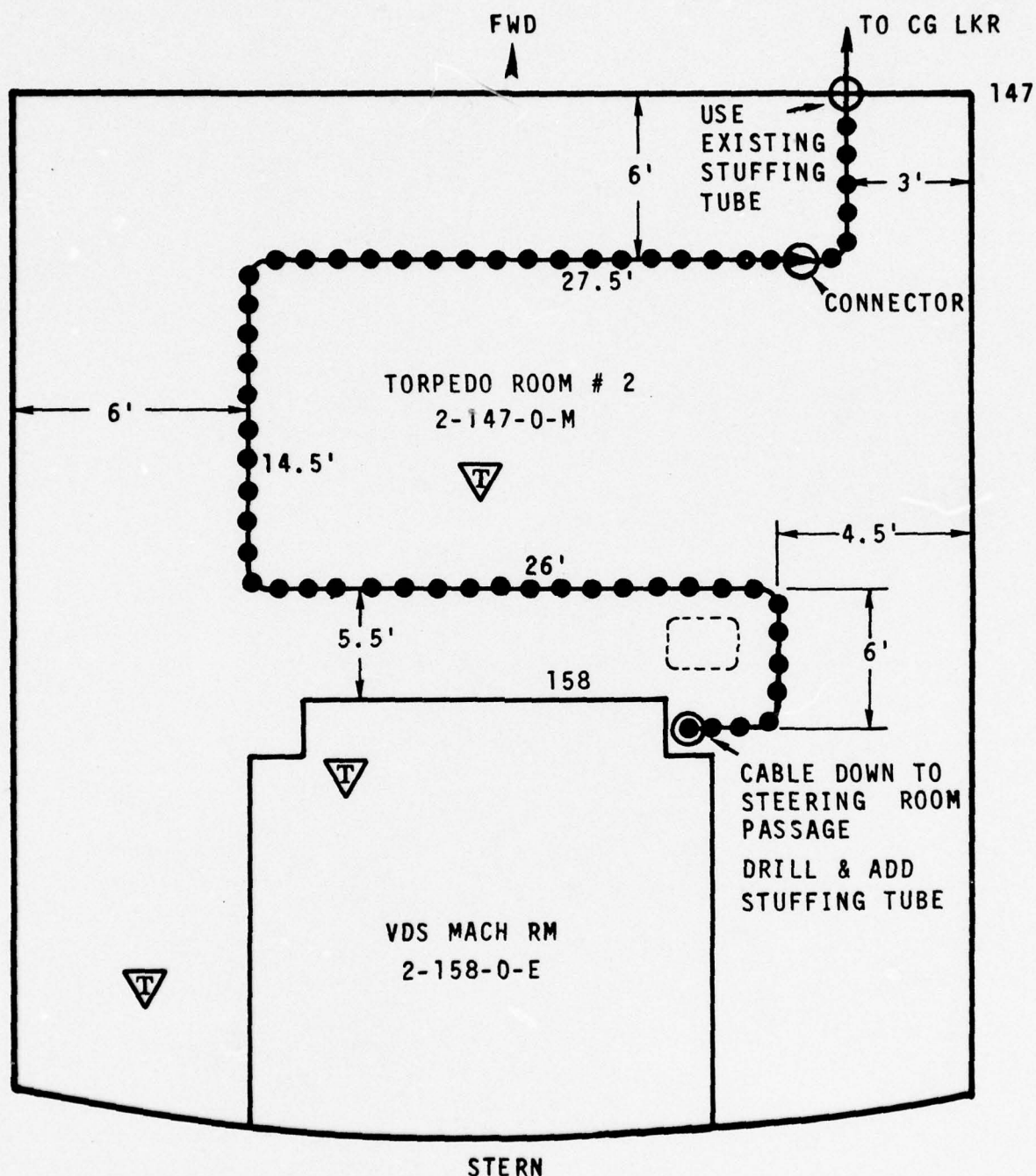
FIG 3-2



NOTE: USE EXISTING CABLEWAYS AND BULKHEAD PENETRATIONS

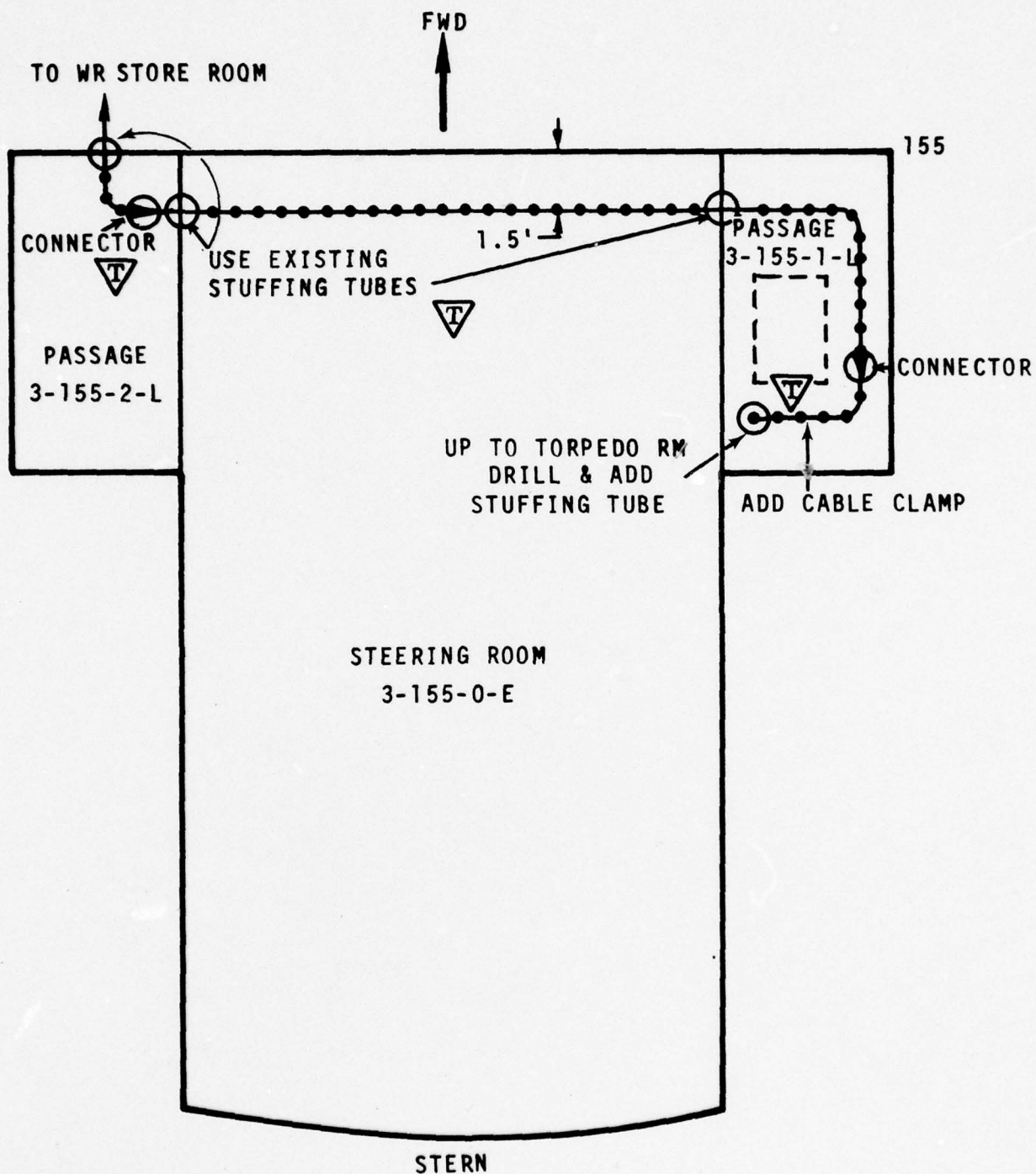
NOTE: APPROX CABLE LENGTH ON THIS FIG. \approx 66 FT.

FIG 3-3



NOTE: USE EXISTING CABLEWAYS
 NOTE: APPROX CABLE LENGTH
 ON THIS FIG = 84 FT

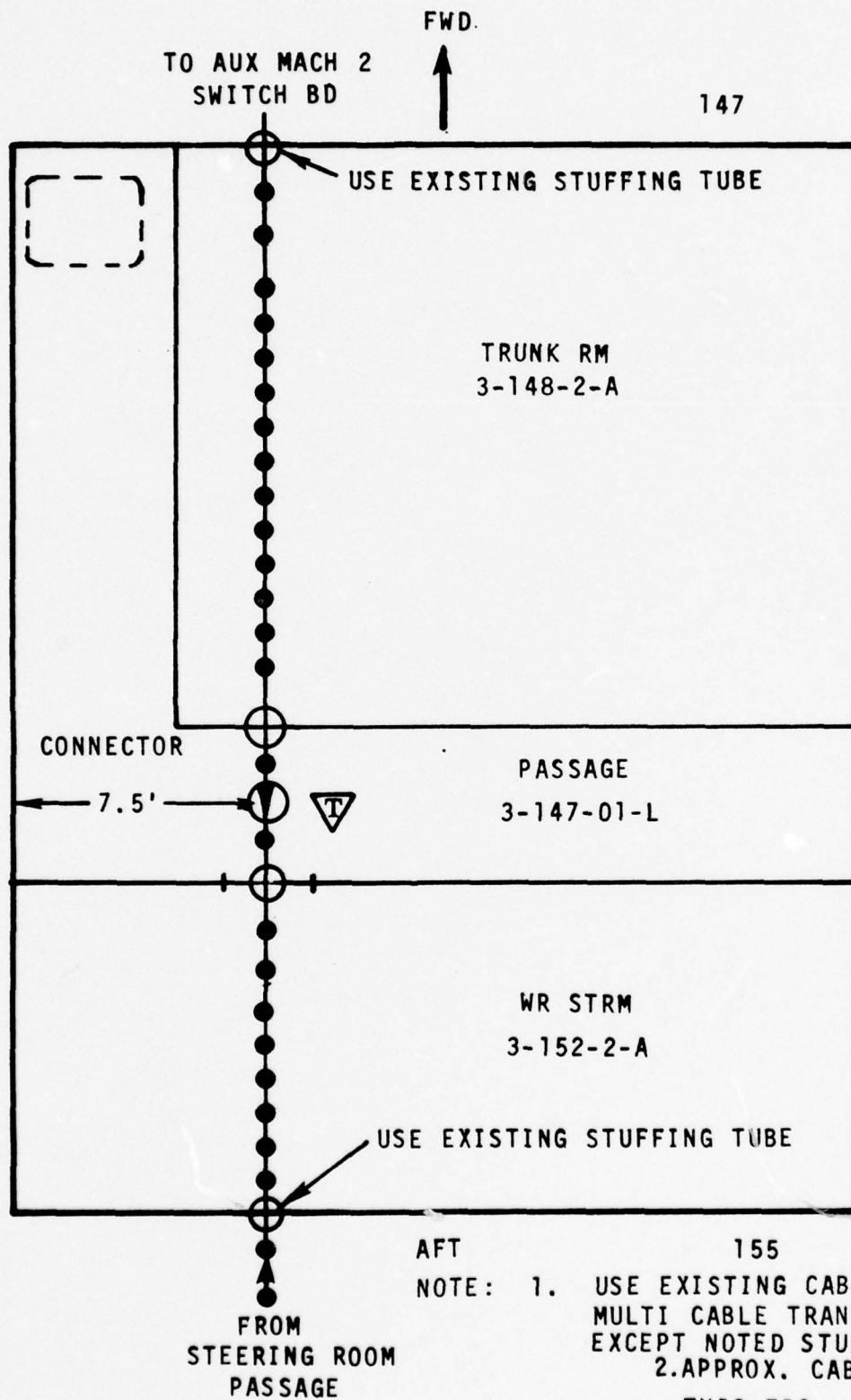
FIG 3-4



NOTE: USE EXISTING CABLEWAYS

NOTE: APPROX CABLE LENGTH THIS FIG (INCLUDING VERTICALS) \approx 46 FT.

FIG 3-5

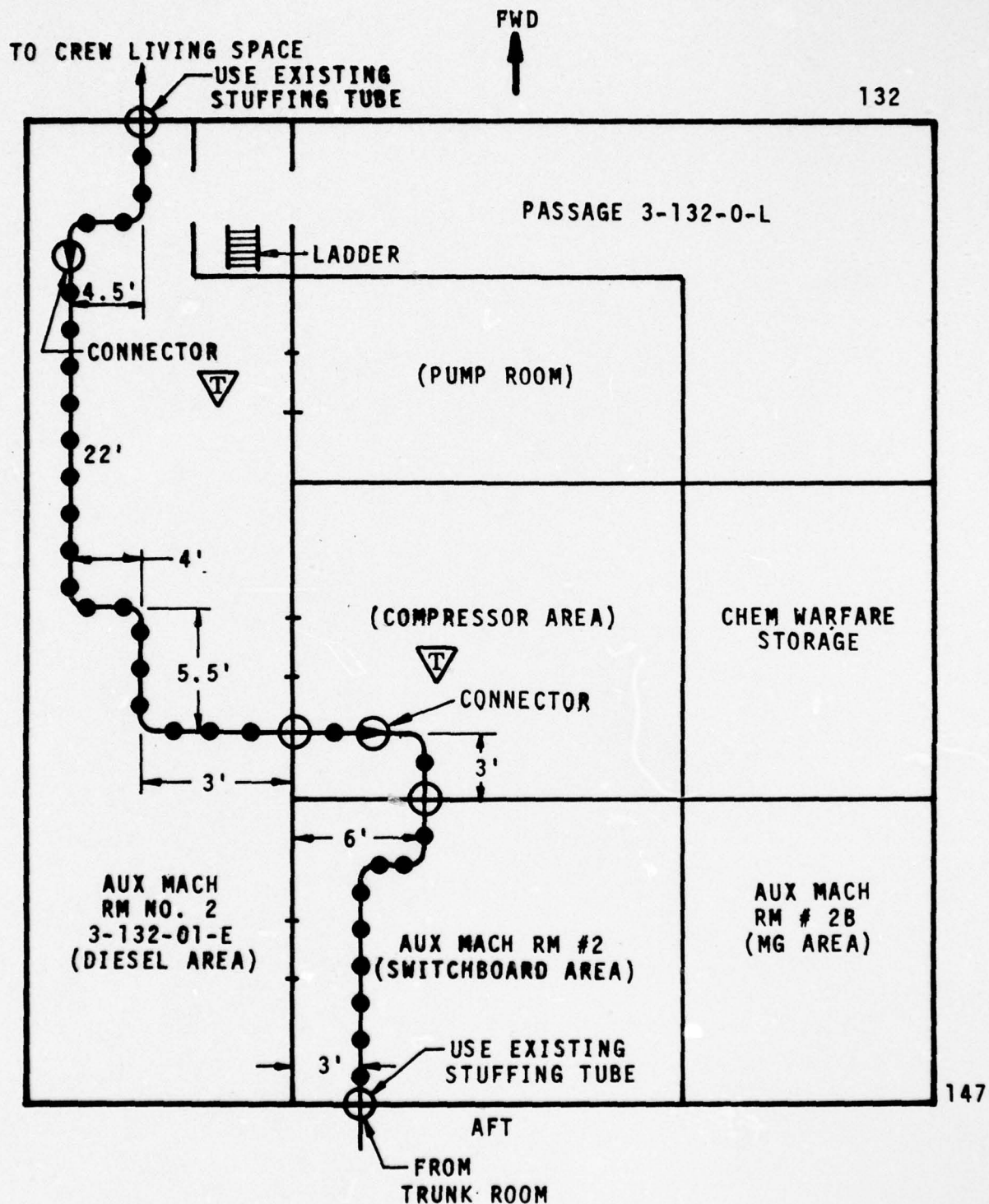


AFT

155

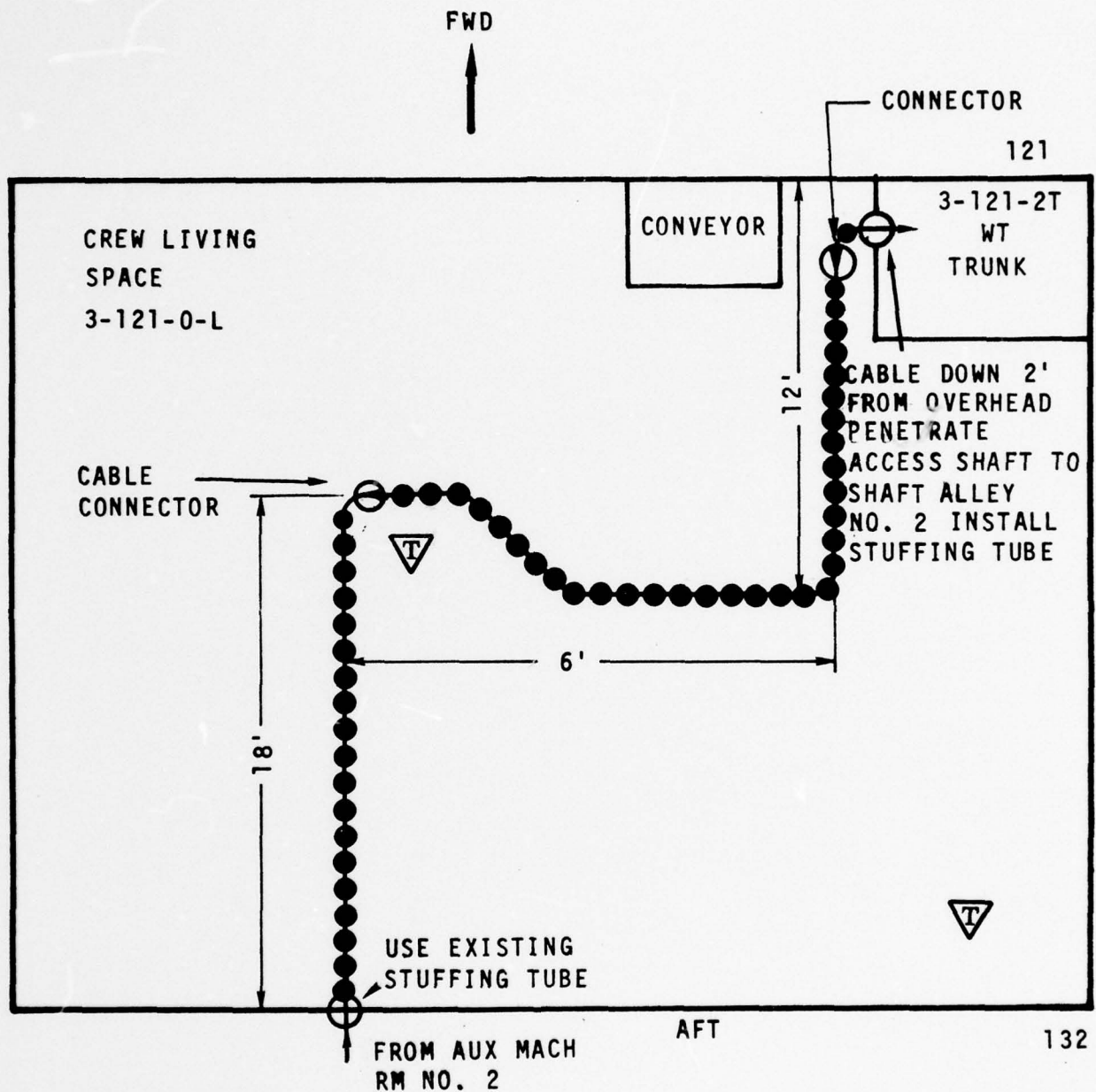
- NOTE: 1. USE EXISTING CABLEWAYS AND MULTI CABLE TRANSIT FRAMES EXCEPT NOTED STUFFING TUBES
 2. APPROX. CABLE LENGTH
 THIS FIG. = 21 FT

FIG 3-6



NOTE: USE EXISTING CABLEWAYS UNLESS OTHERWISE AND EXISTING MULTI-CABLE TRANSIT FRAMES EXCEPT NOTED STUFFING TUBES.
APPROX CABLE LENGTH THIS FIG. 59 FT.

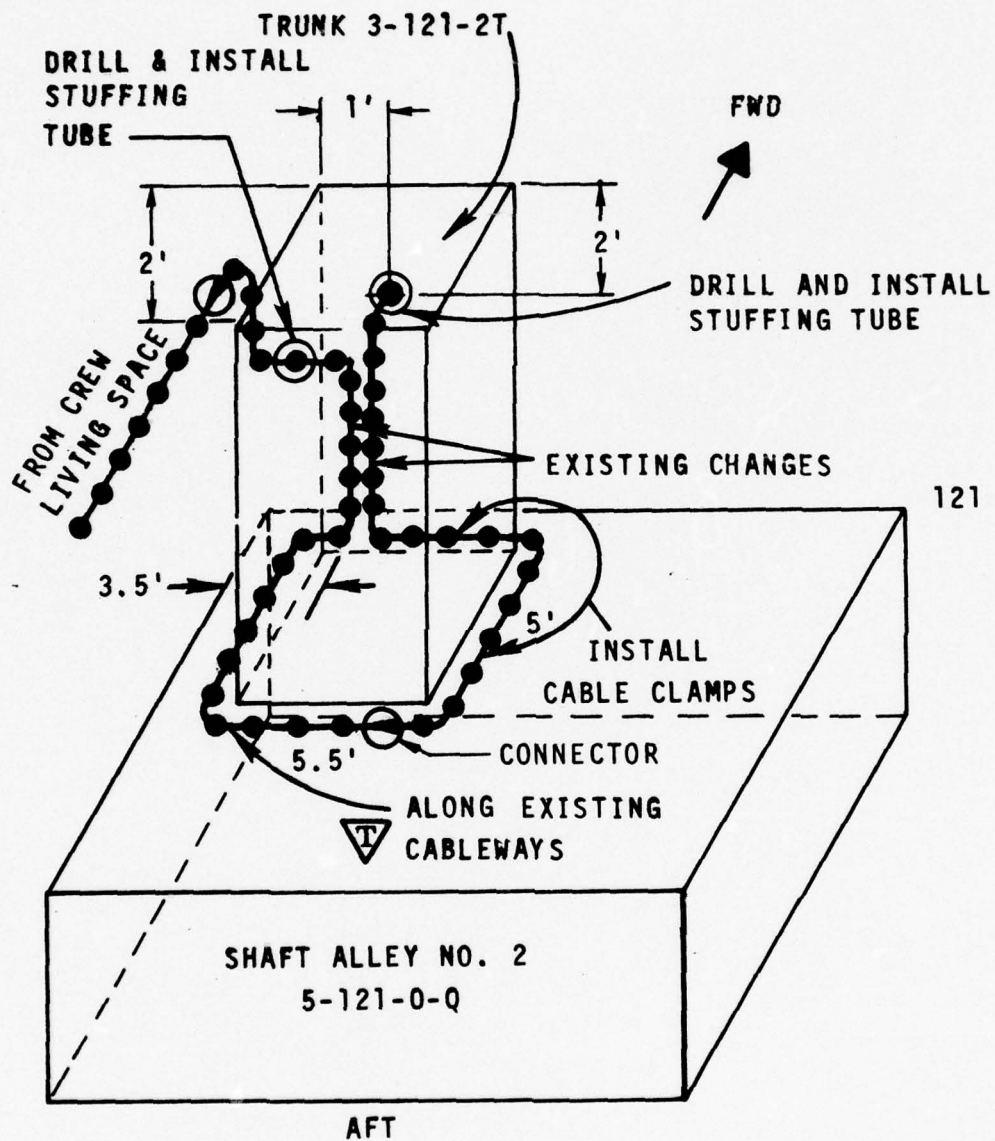
AUXILIARY MACHINERY ROOM NO. 2 3-132-01-E



NOTE: FOLLOW EXISTING CABLEWAYS

NOTE: APPROX CABLE LENGTH THIS
FIG = 38 FT

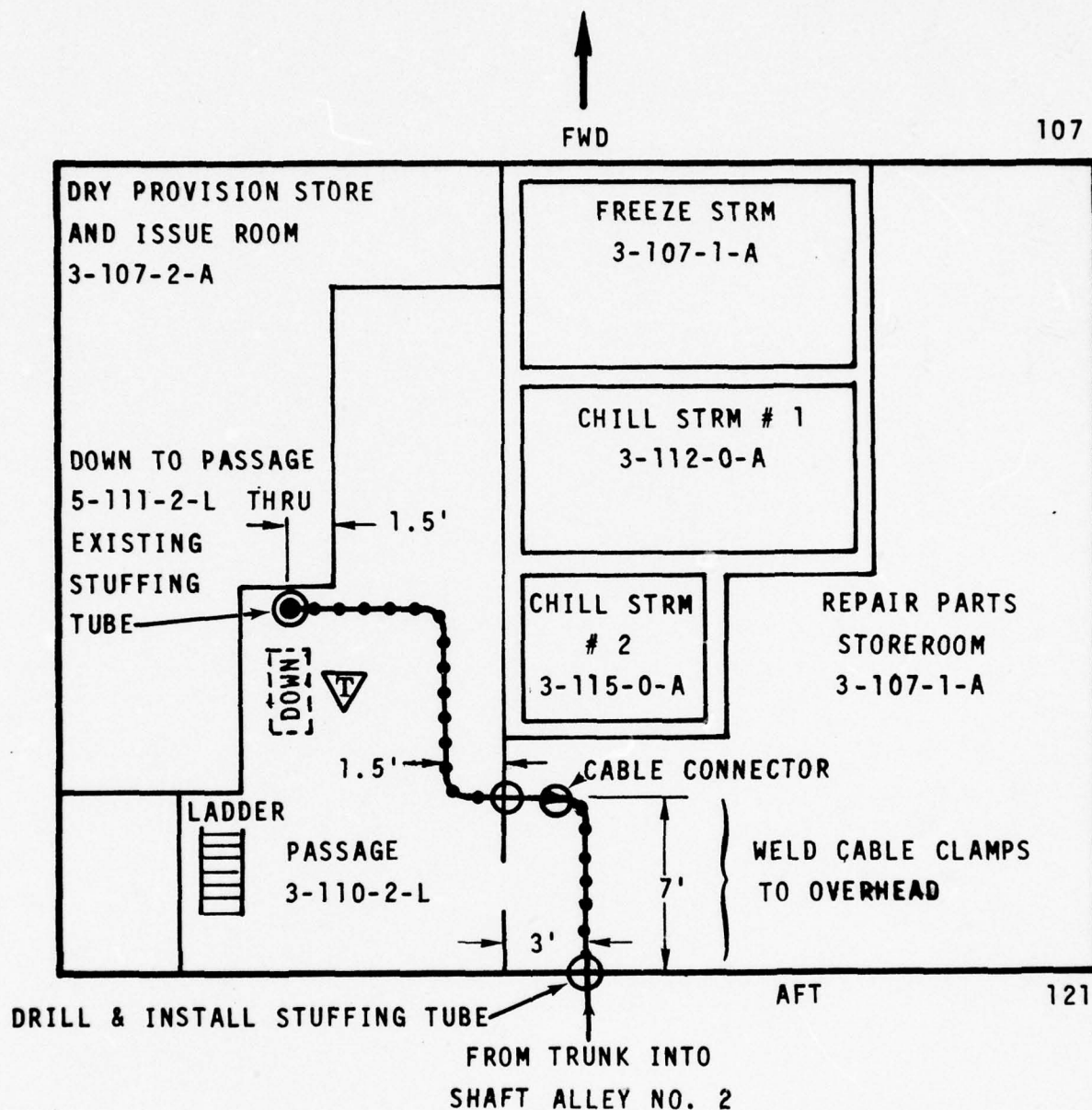
FIG 3-8



NOTE: USE EXISTING CABLEWAYS
UNLESS OTHERWISE INDICATED

NOTE: APPROX CABLE LENGTH THIS
FIG (INCLUDING VERTICALS)
= 36 FT

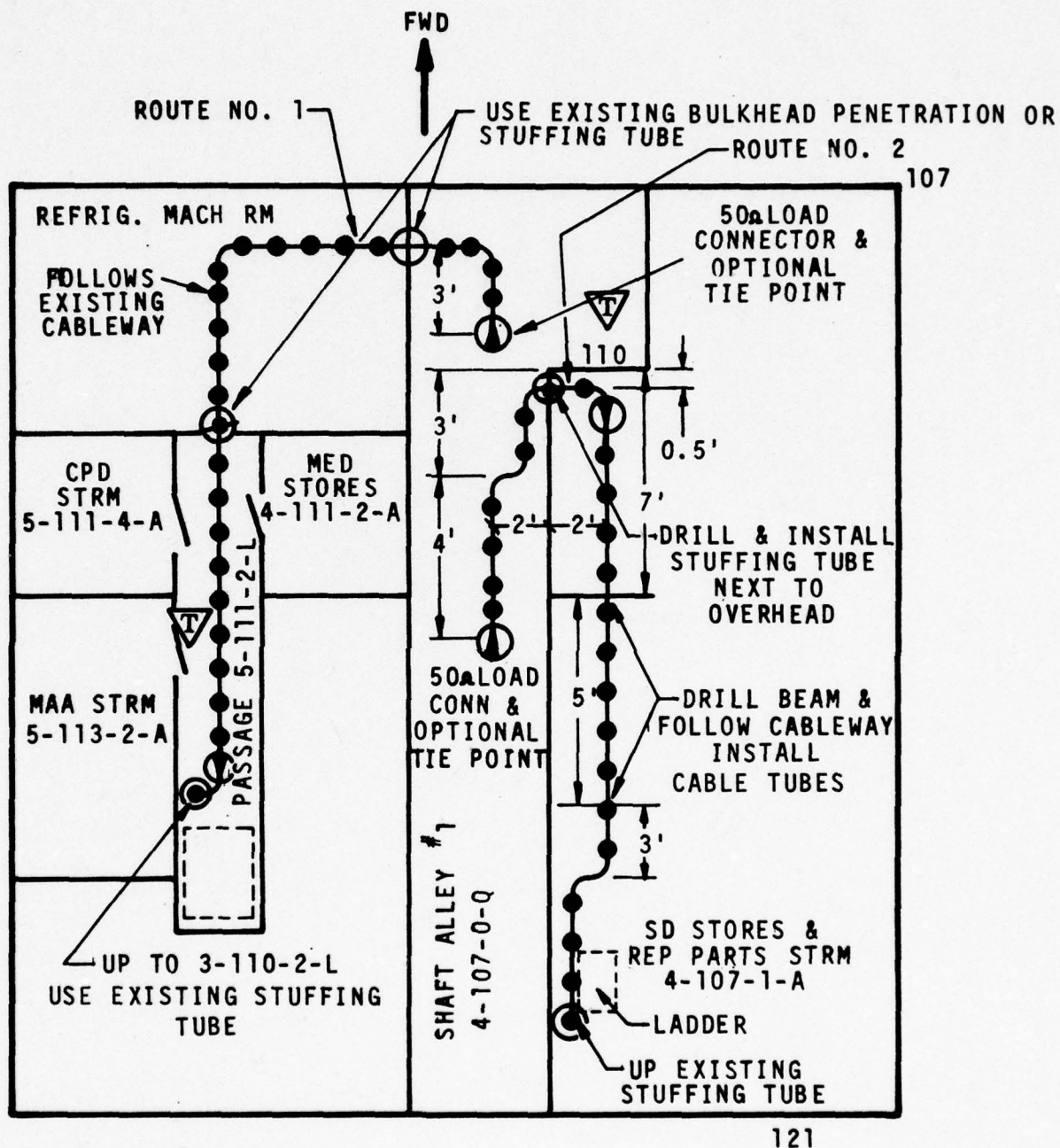
FIG 3-9



NOTE: USE EXISTING CABLEWAYS UNLESS OTHERWISE INDICATED AND EXISTING BULKHEAD PENETRATIONS EXCEPT NOTED STUFFING TUBES.

NOTE: APPROX CABLE LENGTH THIS FIG (INCLUDING VERTICALS) \approx 32 FT

FIG 3-10



NOTE: APPROX CABLE LENGTH ROUTE 2 ON THIS FIGURE
(INCLUDING VERTICALS) = 43 FT
APPROX CABLE LENGTH ROUTE 1 ON THIS FIG \approx 38 FT.

FIG 3-11

APPENDIX 4

Forward Radiax Route

Base Station at Engine Control Station

SIGNIFICANCE OF SYMBOLS



DECK PENETRATION OF STUFFING TUBE



BULKHEAD PENETRATION OR STUFFING TUBE



MULTICABLE TRANSIT FRAME



CONNECTOR

FEMALE MALE



CABLE SPLICE



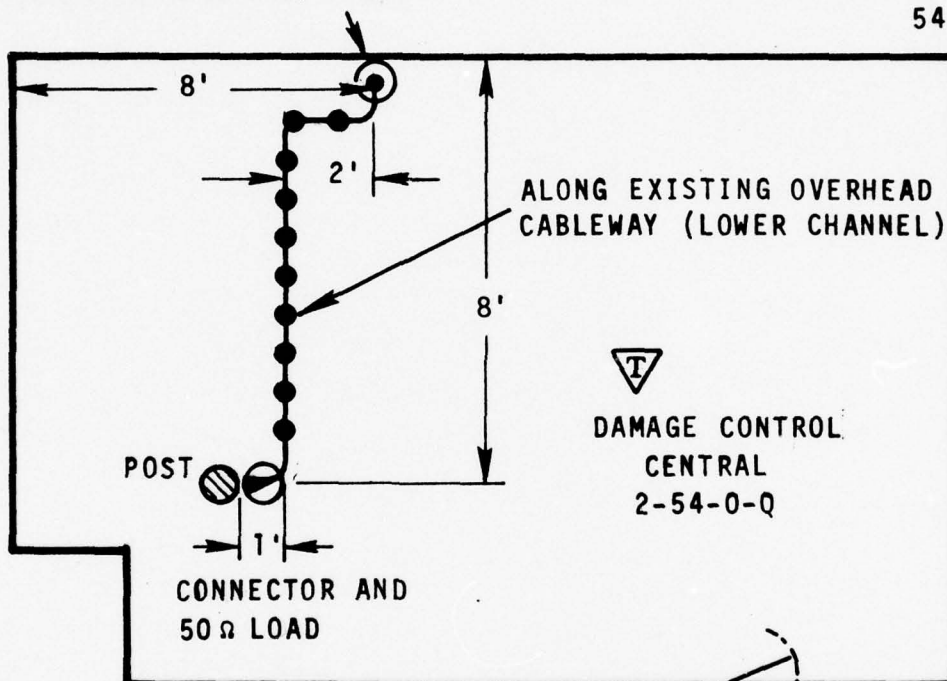
TRANSCIEVER LOCATION DURING TEST

DOWN TO WORKSHOP
FOLLOWING EXISTING CABLEWAY
USE EXISTING STUFFING TUBES

FWD



54



AFT

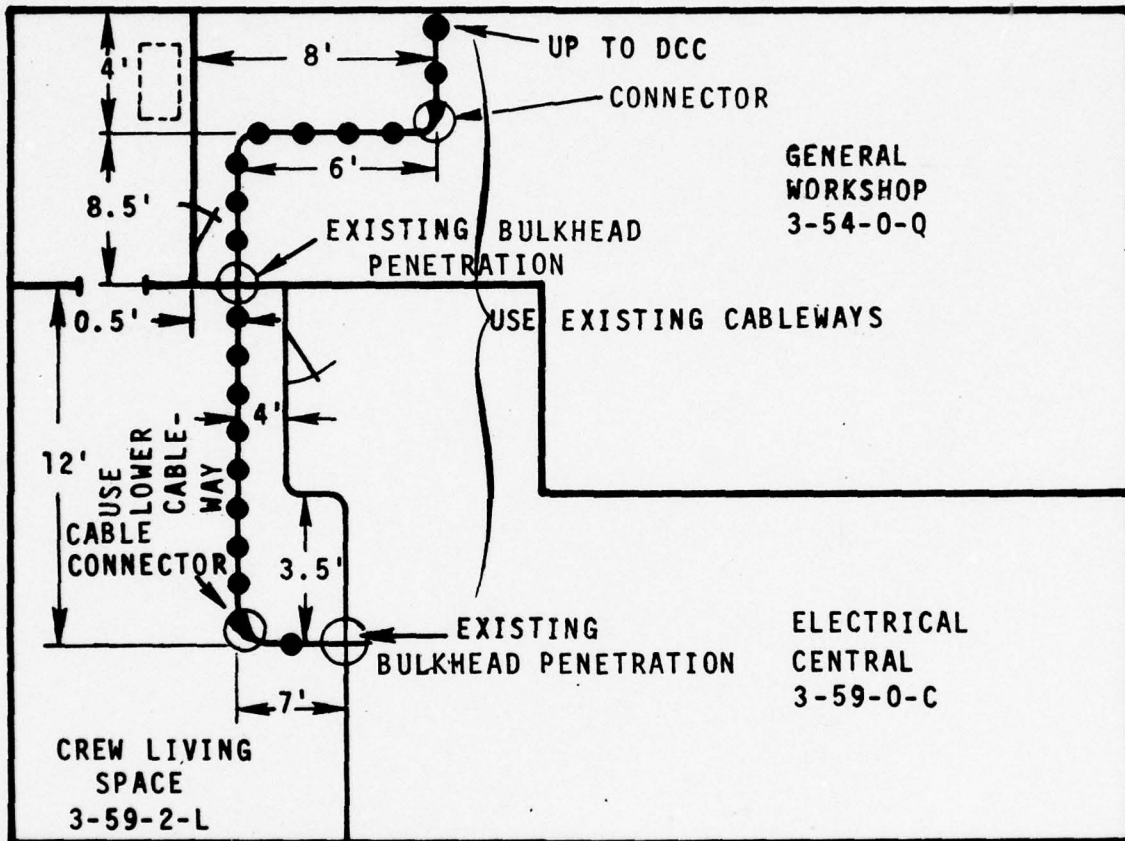
NOTE: APPROX CABLE LENGTH
ON THIS FIG. (INCLUDING
VERTICALS) = 23 FT.

FIG 4-1

FWD

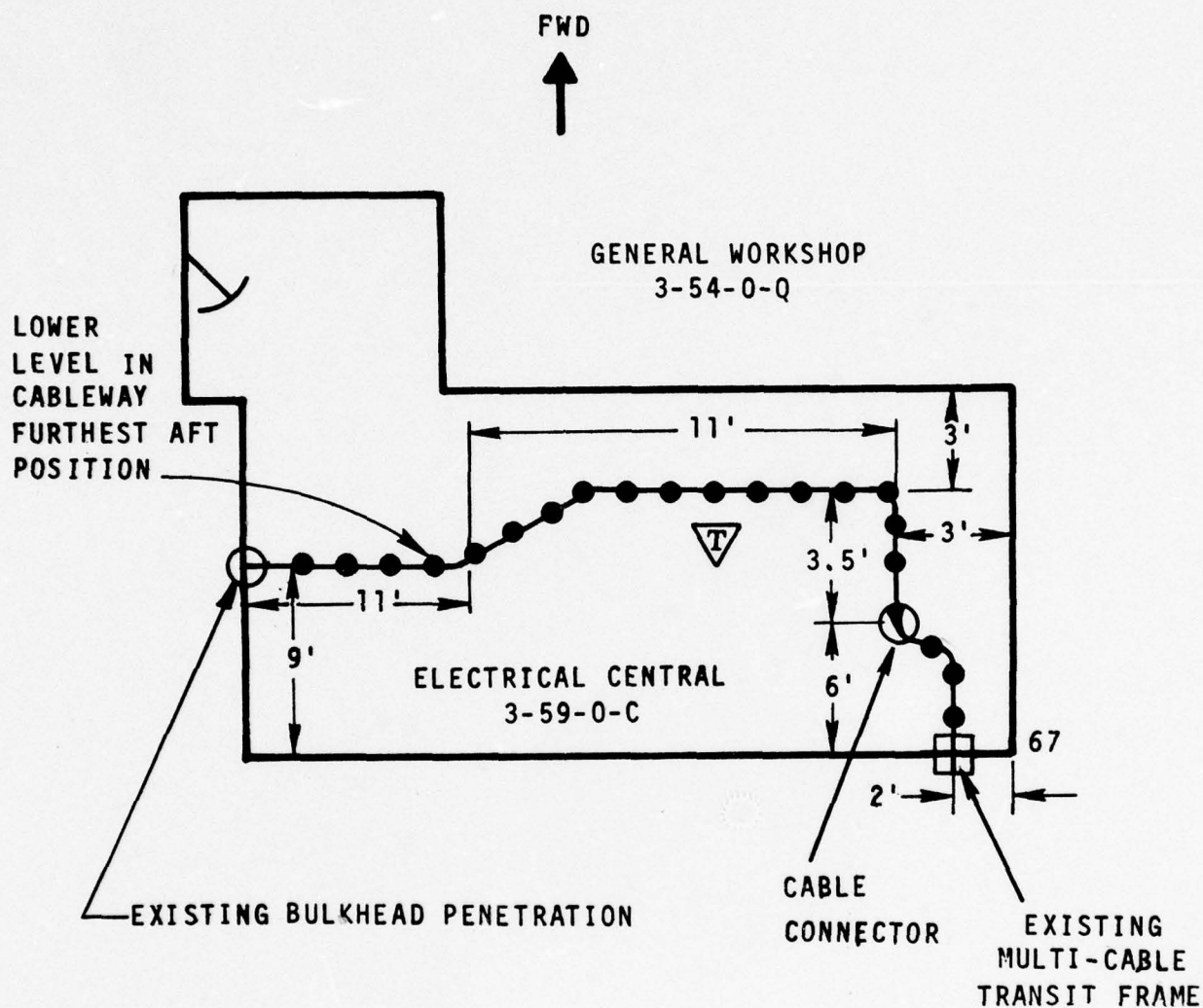


54



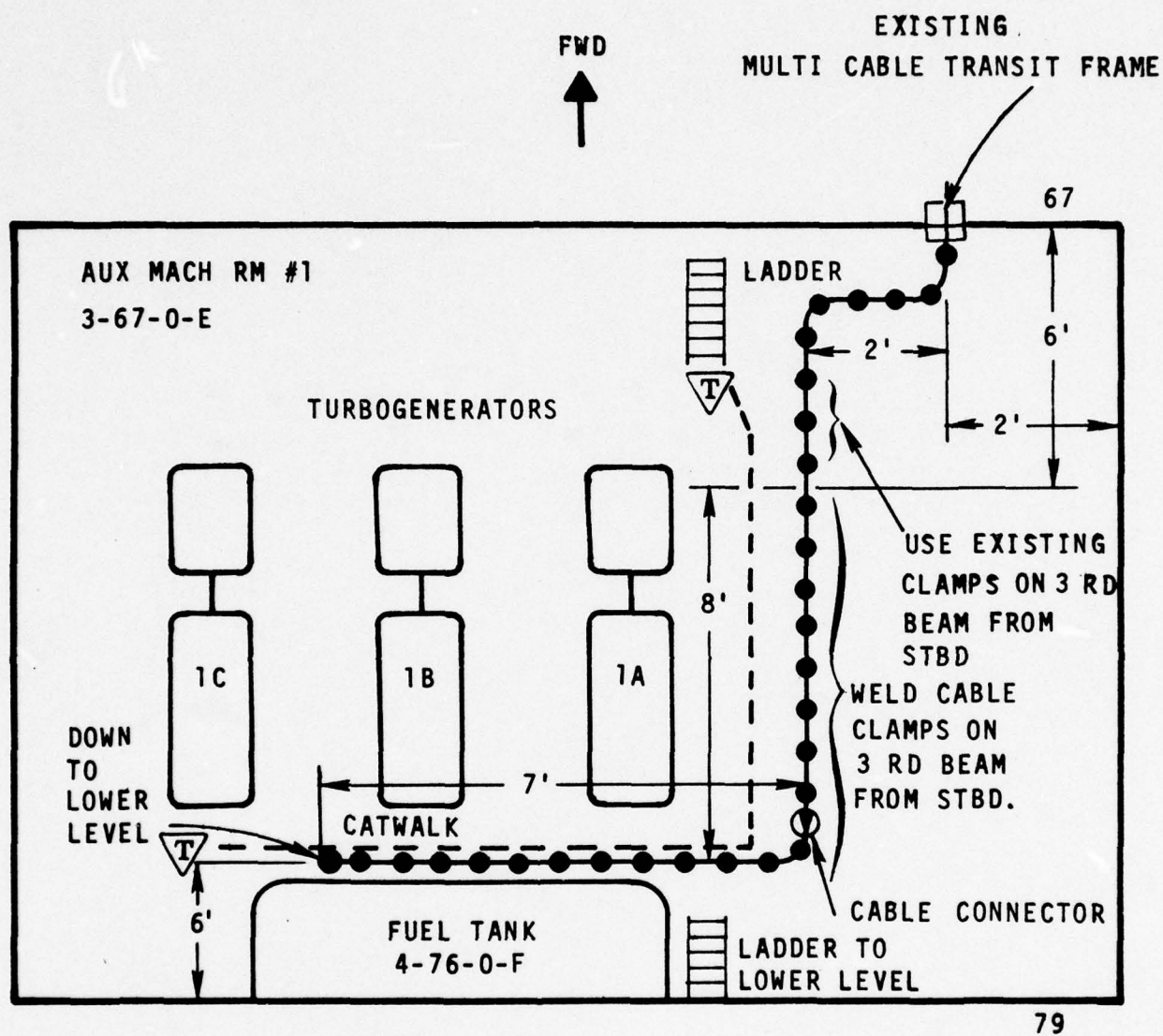
NOTE: APPROX. CABLE LENGTHS
ON THIS FIG. = 38 FT

FIG 4-2



NOTE: APPROX CABLE LENGTHS ON THIS FIG. ≈ 34 FT.

FIG 4-3



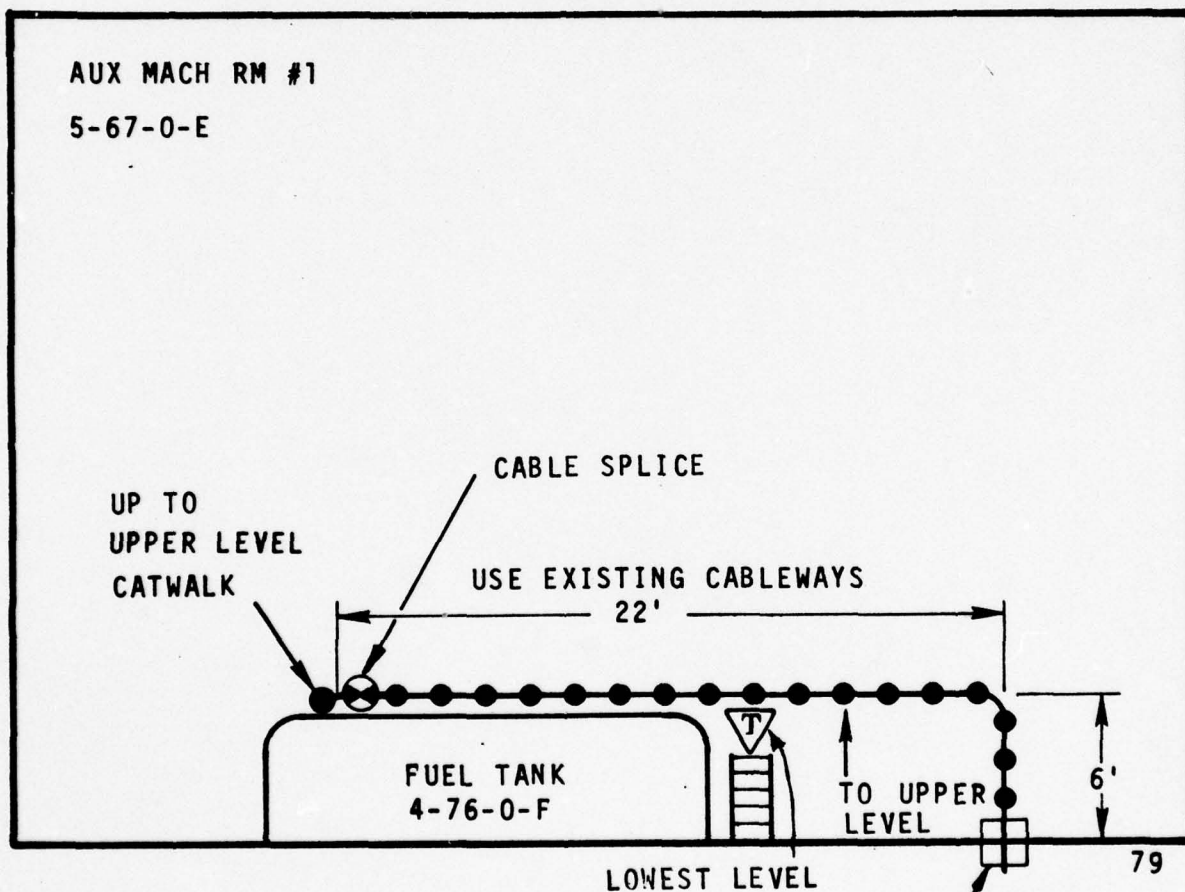
NOTE: APPROX CABLE LENGTHS
ON THIS FIG (INCLUDING
VERTICALS) \approx 41 FT

FIG 4-4

FWD



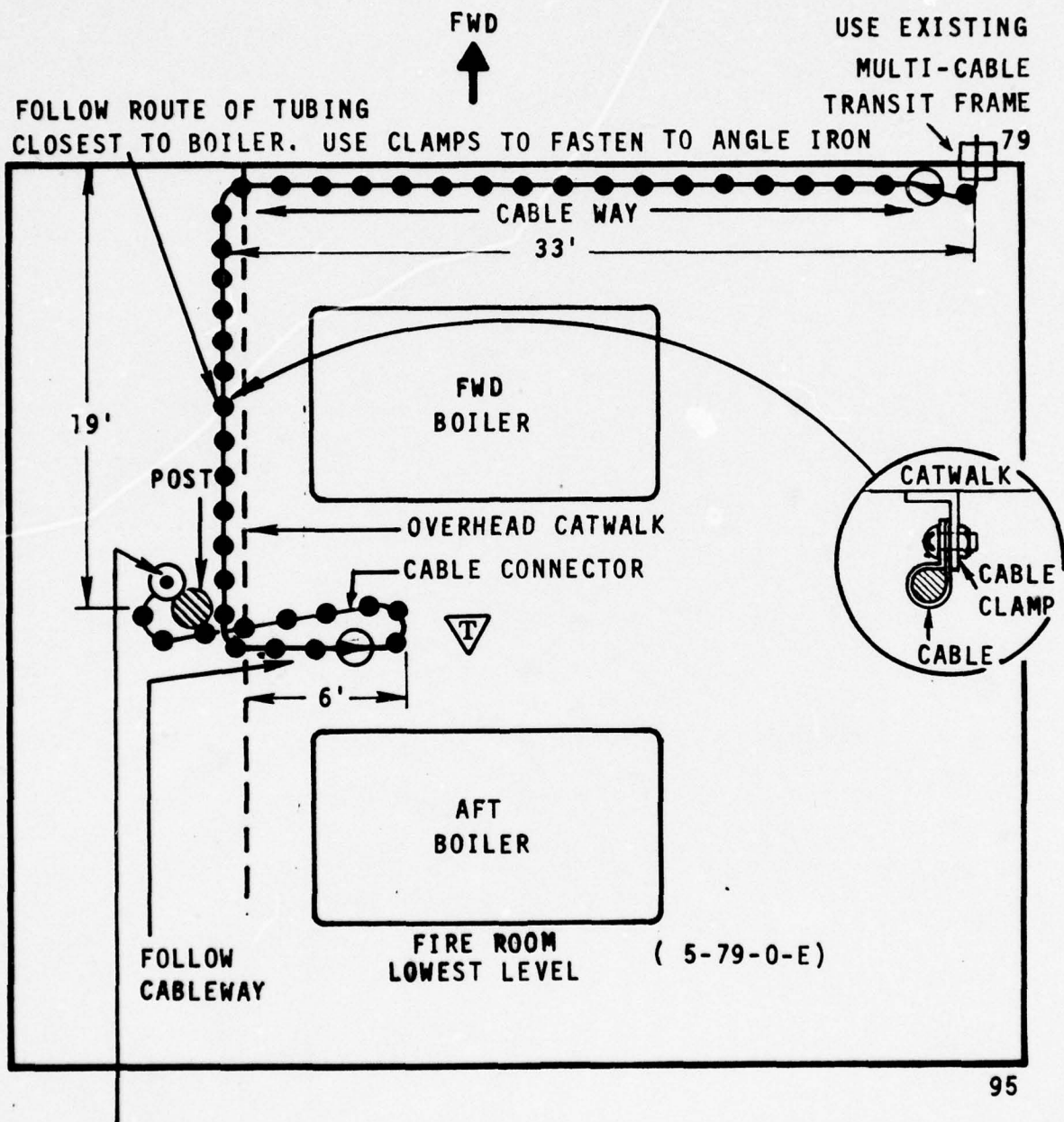
67



NOTE: EXISTING MULTI-CABLE
TRANSIT FRAME
TO FIRE ROOM AT LOWEST LEVEL

APPROX. CABLE LENGTHS IN
THIS FIG. ≈ 28 FT.

FIG 4-5



FOLLOW CABLE AROUND POST AND UP WITH OTHER EXISTING CABLES THRU EXISTING STUFFING TUBE TO FIRE CONTROL ROOM

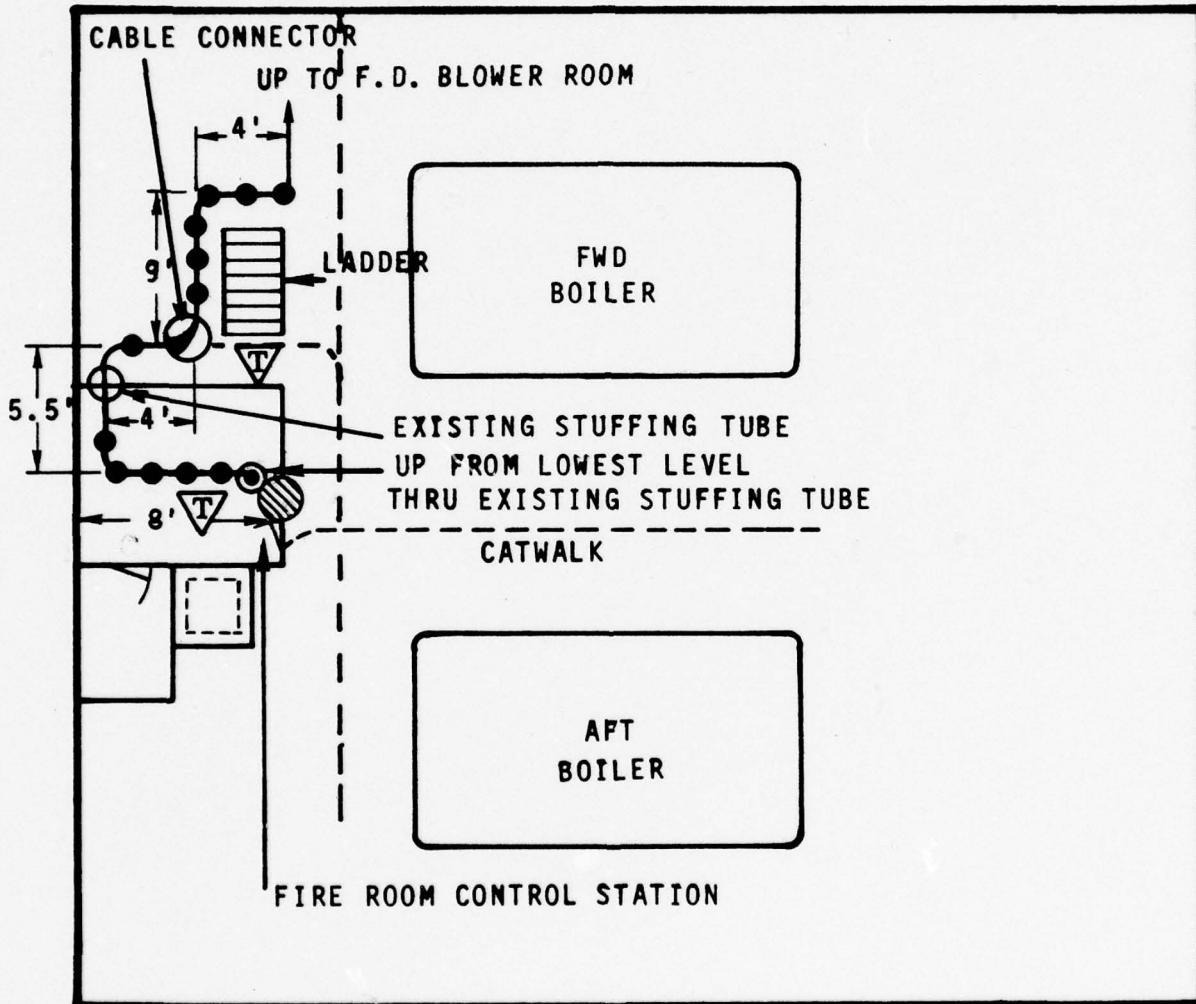
NOTE: APPROX CABLE LENGTH ON THIS FIG (INCLUDING VERTICALS) = 75 FT

FIG 4-6

FWD



79



95

FIG 4-7 NOTE: APPROX CABLE LENGTH ON THIS FIG. (INCLUDING VERTICALS) = 50 FT.

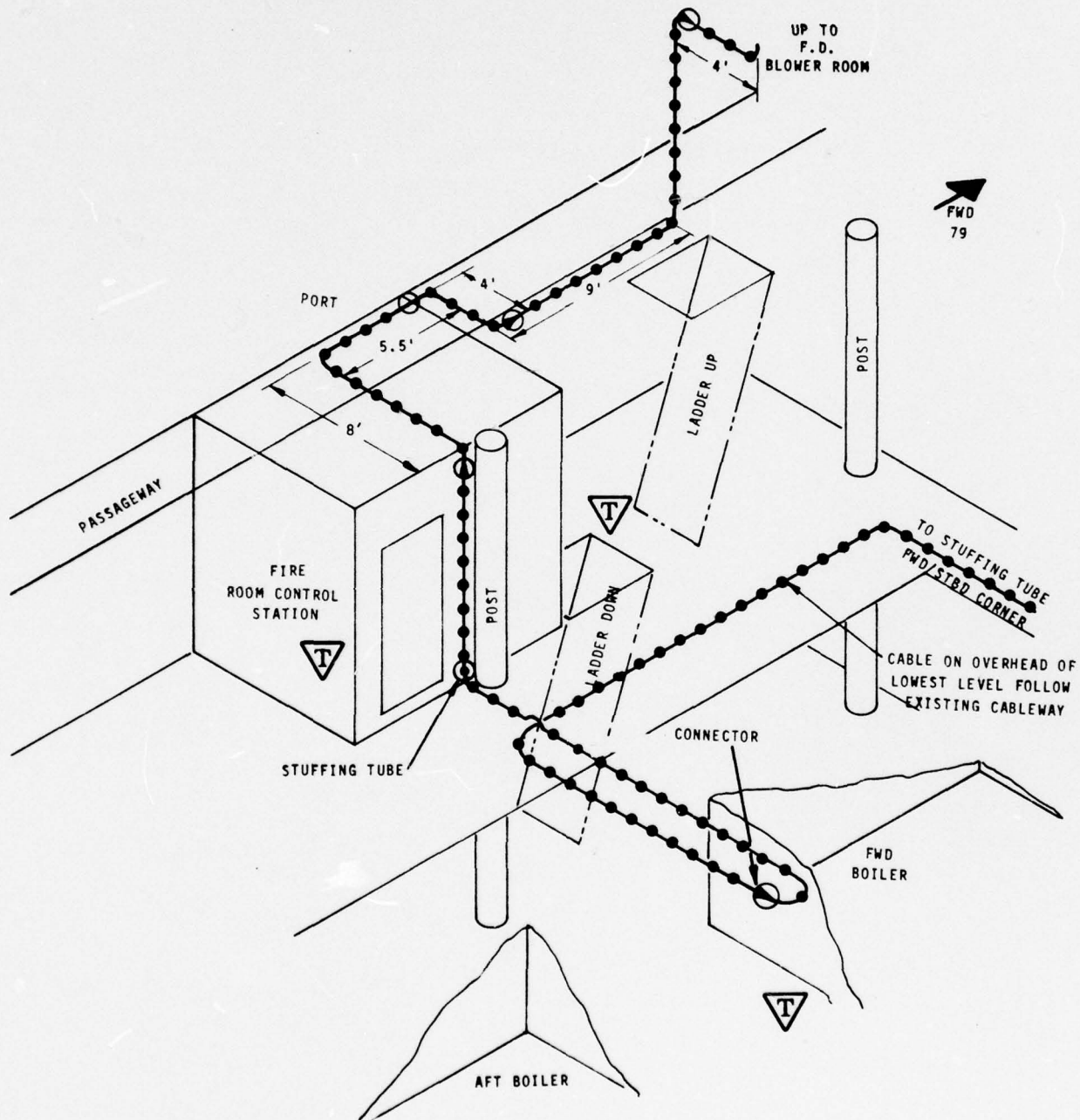


FIG 4-8

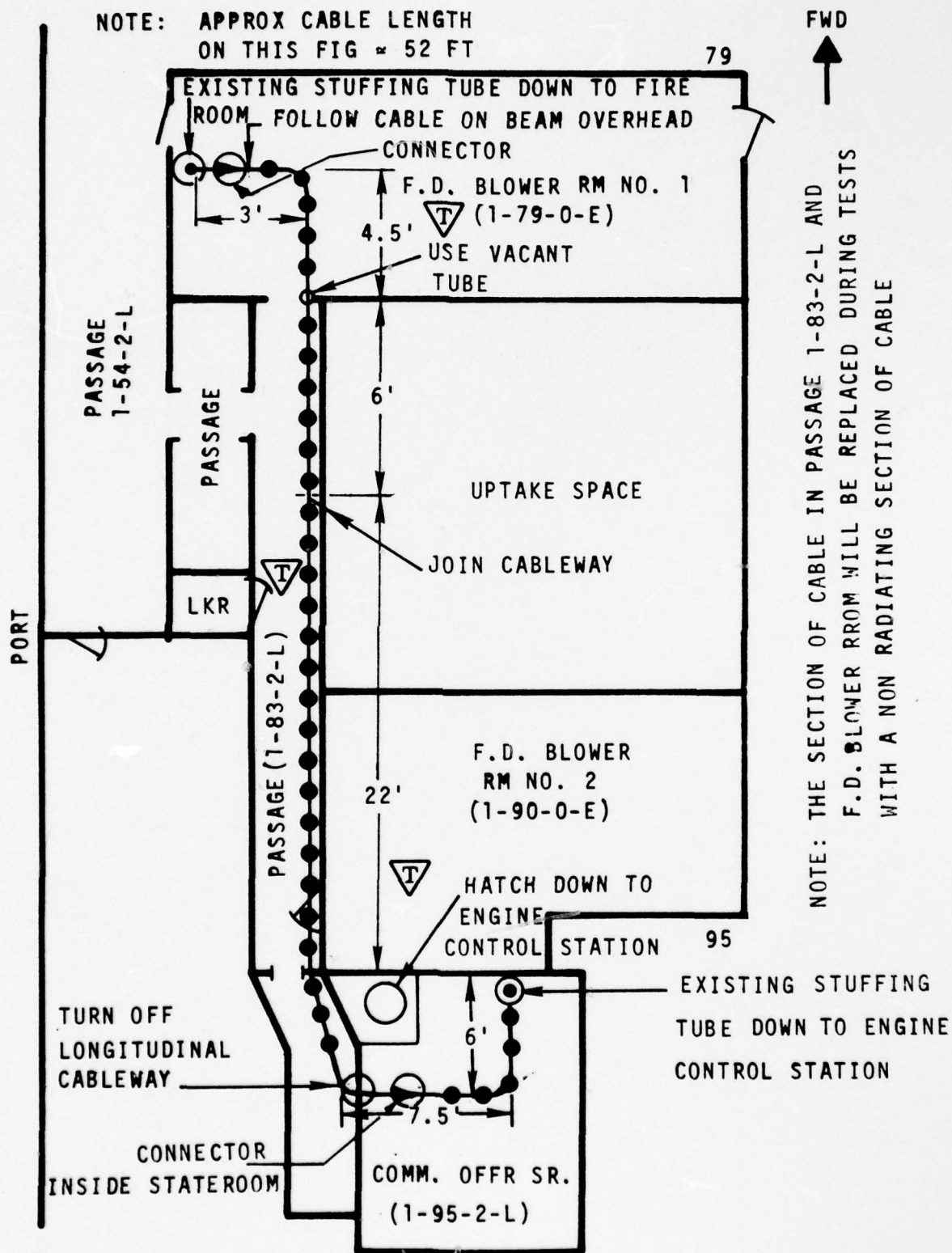
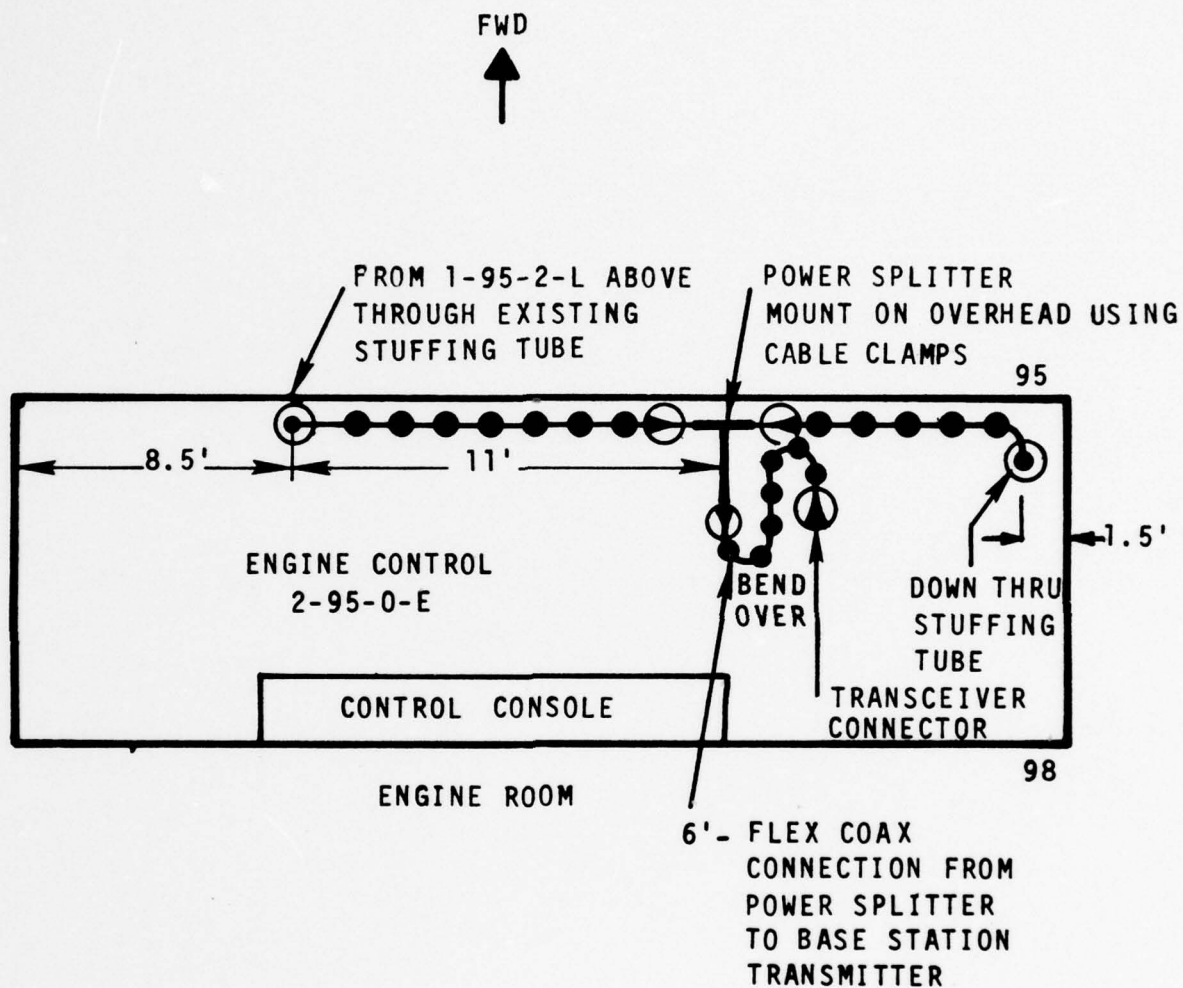


FIG 4-9



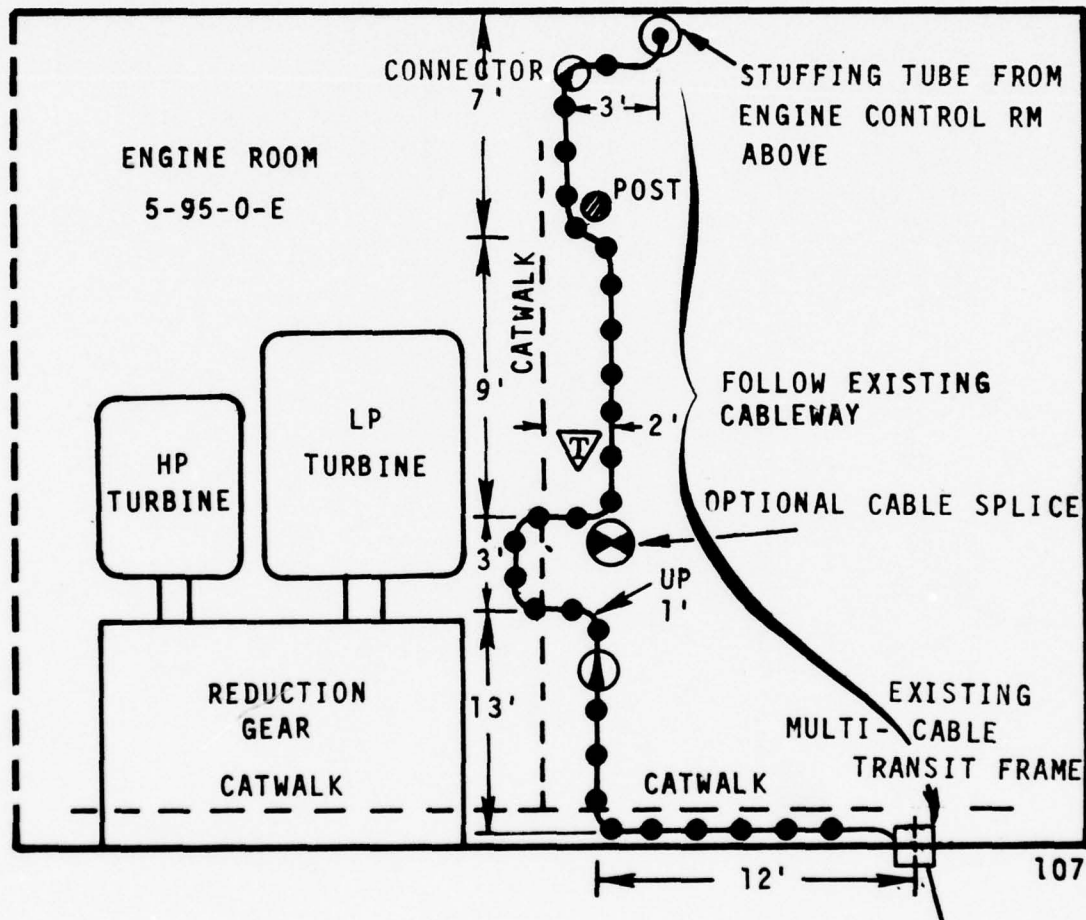
NOTE: APPROX CABLE LENGTH
ON THIS FIG
(INCLUDING VERTICALS)
≈ 38 FT.

FIG 4-10

FWD

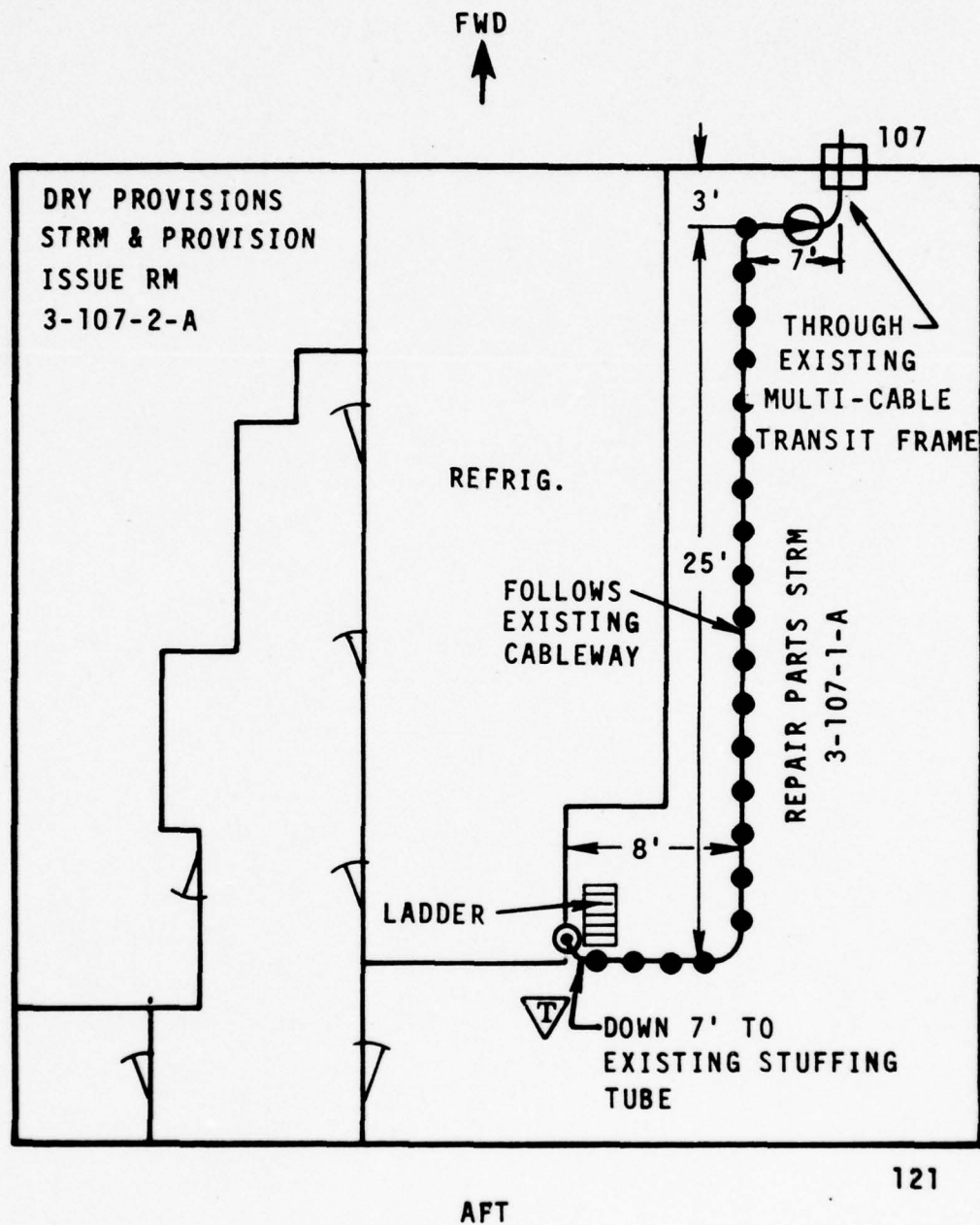


95



NOTE: APPROX CABLE LENGTH ON THIS
FIG. (INCLUDING VERTICALS)
≈ 59 FT

FIG 4-11



NOTE: APPROX CABLE LENGTH ON THIS
FIG = 43 FT.

FIG 4-12

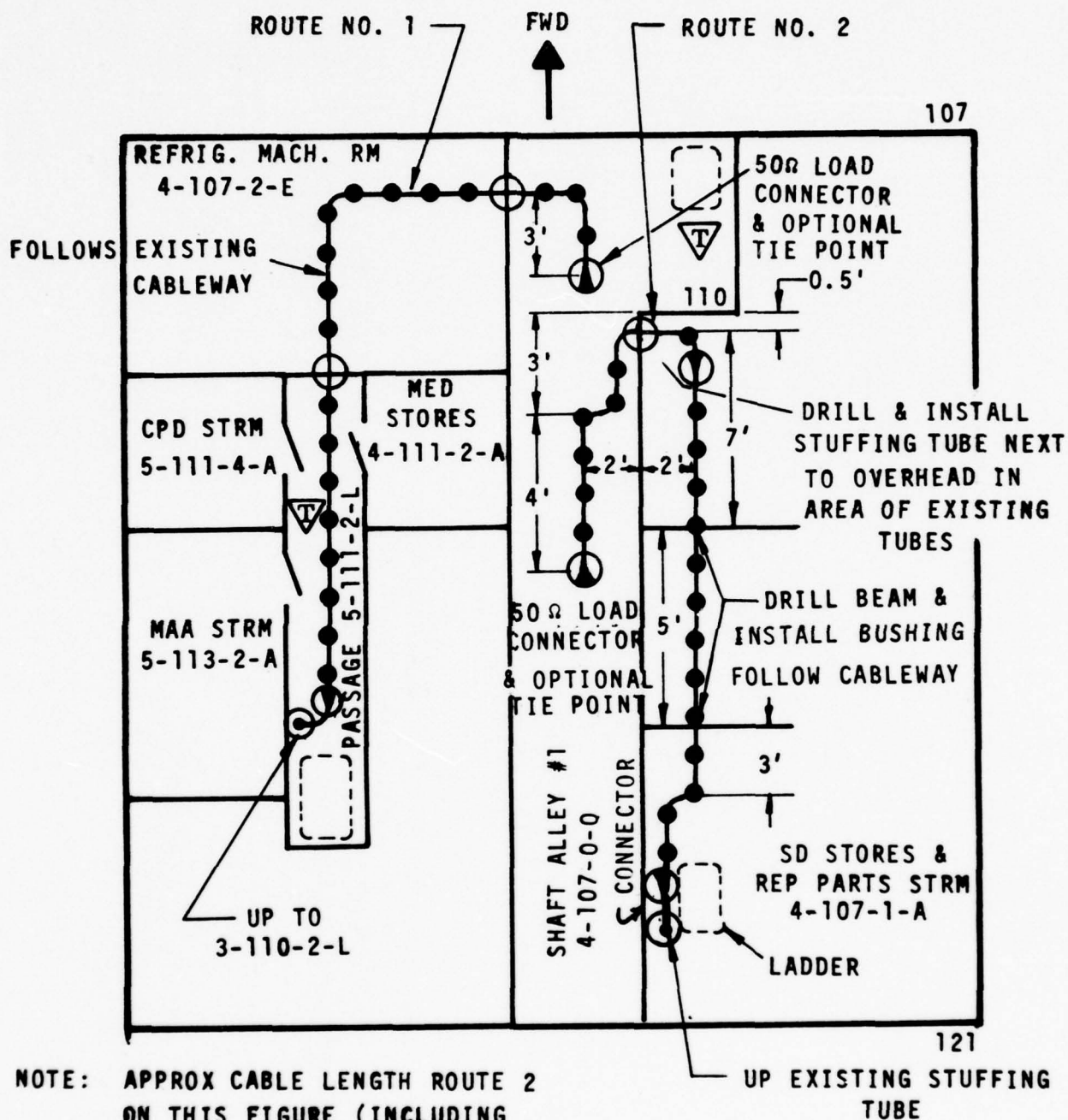


FIG 4-13

APPENDIX 5

Penetrations

Several types of bulkhead and deck penetrations applicable to the Radiax installation are found in NAVSEC Drawing No. 9000-S6202-73980. Pertinent sheets from that document are reproduced in this appendix. These are numbered with the same sheet numbers as in 73980. The applicable sheets are indexed below.

	Bulkhead Penetration	Deck Penetration
Non-watertight	Sheet 18, 20, 21 1, 2	26 1, 2
Watertight, single cable	Sheet 14 1, 2	13 1, 2
Watertight, multicable	Sheet 170 - 173	

The MIL-S-24235 stuffing tube is size C for .625 cable, Assembly M24235/9-003 and requires packing assembly MIL-P-16685D, size C. The tube fits 3/4" pipe.

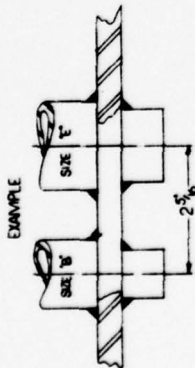
The MIL-S-19622 stuffing tube is size 4T. The pipe version on sheet 13 is M-19622/3-005. It fits a 1" pipe nipple. The style pictured in method 4144, sheet 14, is M-19622/1-004. Both require packing assembly M-19622/19-0004.

To use the multicable transit frame of sheet 172 one of the proper size blank blocks must be replaced with a size 30/15. The block is 30 mm or 1.18 inch square. A double size block (2.36" square) could be replaced with one 30/15 and three 30/0 sizes.

The ship's engineering officer should determine the appropriate optional method. Thus, where welding would be objectionable because of proximity to other cables, method 4262 might be selected in preference to 4261 (sheet 26). Minimum spacing of tubes is called out in sheet 2 but on-site conditions may dictate other spacing. If the available spaces in the multicable transit frame are wrong size the position of a welded pipe to accept an M-24235 stuffing tube should be determined by the ship's engineering officer.

HOLE SPACING IN DECKS AND BULKHEADS
FROM DESIGN DATA SHEET 205/100-2)

411



NOTES-

- 1 THE TABLE REFERRED TO IN THE FOLLOWING NOTES IS THE HOLE SPACING TABLE ON SHEET 2
- 2 THE DIMENSIONS SHOWN IN THE HOLE SPACING TABLE ARE FOR STEEL DECK PLATES, STEEL BULKHEADS, HIGH TENSILE AND MEDIUM STEEL DECKS AND BULKHEADS
- 3 THIS TABLE MAY BE USED FOR ALL PLATE THICKNESSES NOT EXCEEDING 3 INCHES. THIS TABLE DOES NOT APPLY TO ALUMINUM
- 4 THIS TABLE MAY ALSO BE USED FOR ALUMINUM AND BRASS DECKS AND BULKHEADS WHERE INSTALLATION OF STUFFING TUBES ARE REQUIRED
- 5 THE VALUES OF THE TABLE ARE MINIMUM PERMITTED VALUES, AND MAY BE INCREASED AS DESIRED TO BE DESIRABLE FOR ANY PARTICULAR APPLICATION
- 6 WHEN STRENGTH TESTS DO NOT REQUIRE OR INCREASE USE IN THICKNESS OF PLATING OR ADDITION OF DOUBLE PLATES THE METAL RESTORED TO A PLATE BY THE MOUNTING OF STUFFING TUBES OR THE PRESSING OF PIPE IS ADEQUATE COMPENSATION FOR THE METAL REMOVED FROM THE PLATE DUE TO THE DRILLING OF HOLES IN ACCORDANCE WITH THE TABLE, AND VIOLATIONS OF NOTE 7
- 7 THIS TABLE IS APPLICABLE TO THE GREAT MAJORITY OF INSTALLATIONS. EXCEPTIONS TO THE TABLE ARE RECOGNIZED WHEN IT IS EXPEDIENT TO MOUNT STUFFING TUBES ON ALTERNATE SIDES OF THE PLATE BEING PERFORATED AND WHEN SPECIAL FITTINGS ARE USED TO MOUNT STUFFING TUBES ON THE INTERIOR SURFACE OF THE HULL OF BULKHEADS AND CORRUGATED TOWER TRUNKS OR AS OTHERWISE NOTED IN THIS INSTALLATION DRAWING
- 8 FOR STRENGTH PRESERVATION OF BOTH MEDIUM AND SPECIAL TREATMENT STEEL PLATES, STUFFING TUBE HOLE SPACINGS SHALL IN NO CASE BE LESS THAN 10 HOLE DIAMETERS OF ANY TWO HOLE DIAMETERS. FOR SPECIAL TREATMENT STEEL USE THE EXTRA STRENGTH HOLE DIAMETERS GIVEN IN COLUMN THREE OF THE TABLE
- 9 IN LOCATING A HOLE FROM A BOUNDARY STRUCTURAL MEMBER OF CABLE SUPPORT THE DISTANCE SHALL NOT BE LESS THAN HALF THE CENTER TO CENTER SPACING OF THE HOLE FROM THE CENTER OF THE MEMBER
- 10 THIS TABLE DOES NOT APPLY TO RESTRICTIONS ON THE HOLES SHALL BE OBSERVED AS LONG AS THE RESTRICTION REGARDING MINIMUM ALLOWABLE SPACING IS NOT VIOLATED
- 11 THE SPACINGS FOR TUBE SIZES 18 THROUGH 24 ARE SUFFICIENT FOR THE USE OF THE STANDARD OPERATING MACHINES SPEC. M.L.W. 1000. FOR TUBE SIZES 24 THROUGH 30 THE SPACINGS ARE SUFFICIENT FOR THE USE OF 1000 AND THE CORRECT MACHINES WITH SQUARE DRIVE. BUREAU DEVELOPED. THIS DOES NOT HOWEVER EXCLUDE THE USE OF OTHER TYPES OF MACHINES SUITABLE FOR THE PURPOSE.

NAVY DEPARTMENT		WASHINGTON 10	
BUREAU OF SHIPS		ELECTRIC PLANT INSTALLATION	
STANDARD METHODS		MINIMUM SPACING OF HOLES FOR STUFFING TUBES AND KICKAPES IN METAL DECKS AND BULKHEADS	
EXAMINED	APPROVED	DATE	BY
REVIEWED	REVIEWED	DATE	BY
TRACED	TRACED	DATE	BY
FILED	FILED	DATE	BY
SECTION 4		SHEET 1	
9000		S6202	
73980		SCALE NONE	

HOLE SPACING IN DECKS AND BULKHEADS REPRODUCED FROM DESIGN DATA SHEET DD81002

421

SPACING OF HOLES FOR STUFFING TUBES AND KICKPIPER

THIS TABLE DOES NOT APPLY TO ARMOR PLATE

NOMINAL DIA OF KICKPIPE	DRAW FOR PIPE (STEEL ONLY)	DRAW FOR PIPE (SPECIAL TREATMENT STEEL)	TUBE SIZE	A	B	C	D	E	F	G	J	K	L	M	N	P	R	S	T	V	W	X	Y	Z	AA	BB
3/8"	23 3/32	406	A	1 5/16																						
1/2	7/8	515	B	2"	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16	
3/4	1 3/32	640	C	2 1/8	2 5/16	2 5/16	2 5/16	2 5/16	2 5/16	2 5/16	2 5/16	2 5/16	2 5/16	2 5/16	2 5/16	2 5/16	2 5/16	2 5/16	2 5/16	2 5/16	2 5/16	2 5/16	2 5/16	2 5/16	2 5/16	
1"	1 25/64	812	D	2 1/4	2 3/8	2 3/8	2 3/8	2 3/8	2 3/8	2 3/8	2 3/8	2 3/8	2 3/8	2 3/8	2 3/8	2 3/8	2 3/8	2 3/8	2 3/8	2 3/8	2 3/8	2 3/8	2 3/8	2 3/8	2 3/8	
1"	1 21/64	843	F	2 1/4	2 3/8	2 3/8	2 3/8	2 1/2	2 1/2	2 1/2																
1"	1 21/64	953	G	2 3/8	2 3/4	2 3/4	2 3/4	3"	3"	3"	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	
1 1/4	1 45/64	1062	J	2 3/4	2 5/8	2 5/8	2 5/8	3"	3"	3"	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	
1 1/4	1 43/32	1171	K	2 5/8	2 7/8	2 7/8	2 7/8	3"	3"	3"	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	
1 1/2	1 45/16	1406	M	2 3/4	2 7/8	2 7/8	2 5/16	3"	3"	3"	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	
1 1/2	1 51/16	1515	N	3 1/8	3 3/8	3 3/8	3 1/2	3 3/8	3 3/8	3 3/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	
2"	2 1/32	1625	P	3 3/8	3 7/8	3 7/8	3 1/2	3 3/8	3 3/8	3 3/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	
2"	2 33/32	1750	R	3 3/8	3 7/8	3 7/8	3 1/2	3 3/8	3 3/8	3 3/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	
2"	2 33/32	1875	S	3 5/8	3 7/8	3 7/8	3 1/2	3 3/8	3 3/8	3 3/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	
2 1/2	2 29/32	2062	T	3 5/8	3 7/8	3 7/8	3 1/2	3 3/8	3 3/8	3 3/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	
2 1/2	2 29/32	2187	V	3 11/8	3 3/4	3 3/4	3 3/8	3 5/8	3 5/8	3 5/8	4 1/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	
2 1/2	2 29/32	2312	W	3 11/8	3 3/4	3 3/4	3 3/8	3 5/8	3 5/8	3 5/8	4 1/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	
2 1/2	3 17/32	2507	X	3 11/8	3 3/4	3 3/4	3 3/8	3 5/8	3 5/8	3 5/8	4 1/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	
3"	3 7/32	2609	Y	3 11/8	3 3/4	3 3/4	3 3/8	3 5/8	3 5/8	3 5/8	4 1/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	
3"	3 7/32	2781	Z	3 11/8	3 3/4	3 3/4	3 3/8	3 5/8	3 5/8	3 5/8	4 1/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	
3"	3 7/32	2875	AA	3 3/8	3 7/8	3 7/8	3 3/8	4"	4 1/2	4 1/2	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	
3 1/2	4 3/32	3156	BB	4"	4 1/8	4 1/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	

NAVY DEPARTMENT BUREAU OF SHIPS WASHINGTON D.C.

DESIGNED BY: ELECTRIC PLANT INSTALLATION
 OFFICIAL STANDARD: STANDARD METHODS
 MINIMUM SPACING OF HOLES IN
 STUFFING TUBES AND KICKPIPER
 METAL DECKS AND BULKHEADS

SECTION 4
 SHEET 2

9000 5602 7398
 SCALE: NONE

KICKPIPS THROUGH STEEL, BRASS OR ALUMINUM DECKS STUFFING TUBE - MIL-S-24235 & MIL-S-19622

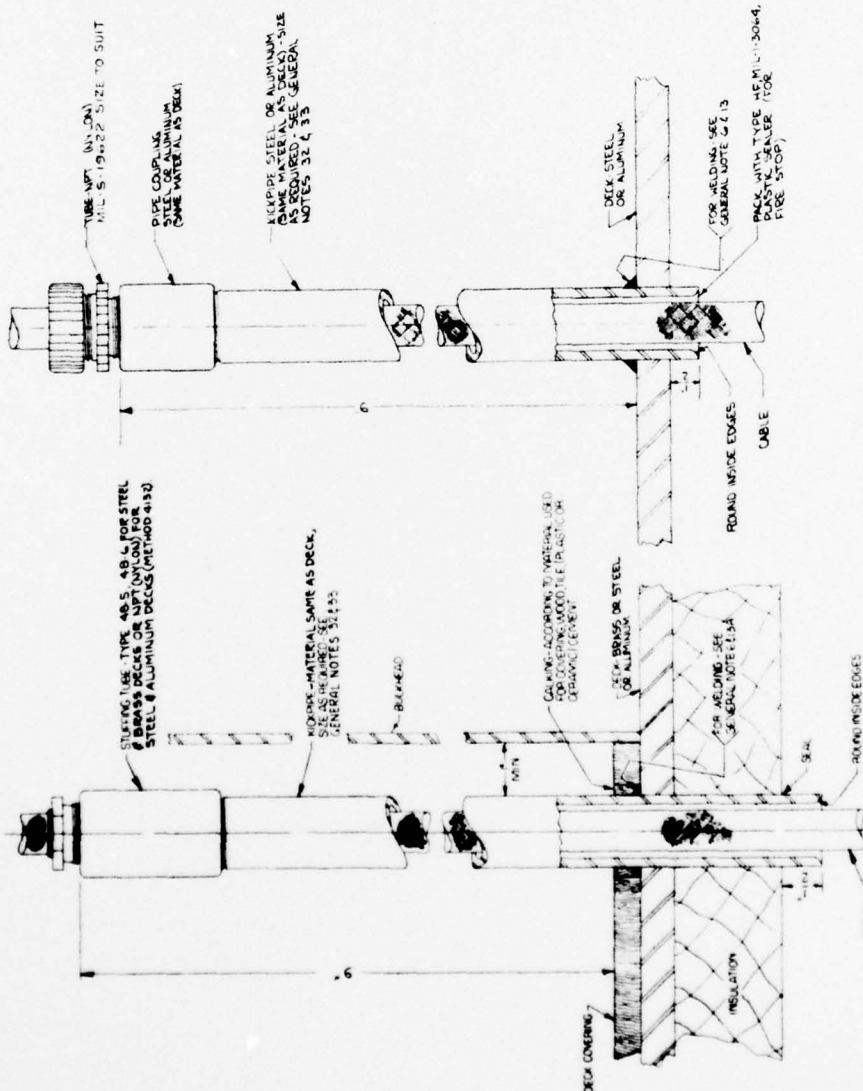
REVISIONS		DATE	BY	REVISION
A	FIRST ISSUE			
B	REVISED ALLIGNS REF	2-70	AMM	
C	EXTENDED APP. CAPABILITY TO ALUMINUM DECKS ADDED METHOD 4132		AMM	
D	UPDATED SHWC			

4131

KICKPIPS THROUGH
WATERTIGHT DECKS WITH COVERING AND
WITHOUT INSULATION

4132

KICKPIPS THROUGH
WATERTIGHT DECKS USING NPT
NYLON STUFFING TUBES

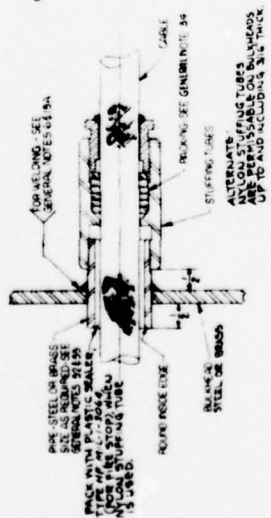


NAVAL SHIP ENGINEERING CENTER WASHINGTON, D.C.	
EXAMINED DATE	APPROVED DATE
ELECTRIC PLANT INSTALLATION STANDARD METHODS FOR PASSING CABLES THROUGH MEDIUM STEEL BRASS OR ALUMINUM DECKS SURFACE VESSELS	
DRAWN BY: [Signature] CHECKED BY: [Signature] DATE: 10-1-69	
SECTION 4 SHEET 13	
PROJECT NO. 79000 56202 73980 D	
SCALE: 1/2"=1'-0"	

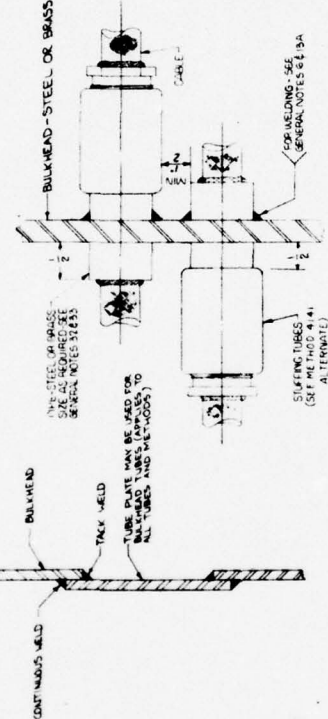
STUFFING TUBES THROUGH MEDIUM STEEL, BRASS OR ALUMINUM BHD

STUFFING TUBE MIL-S-24225 & MIL-S-13622

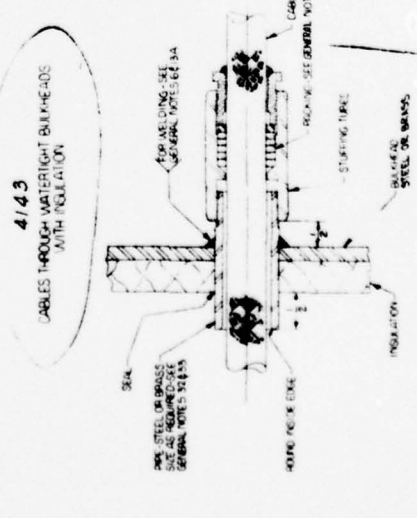
414.1 CABLES THROUGH WATERTIGHT BULKHEADS WITHOUT INSULATION



414.2 STUFFING TUBE PLATE

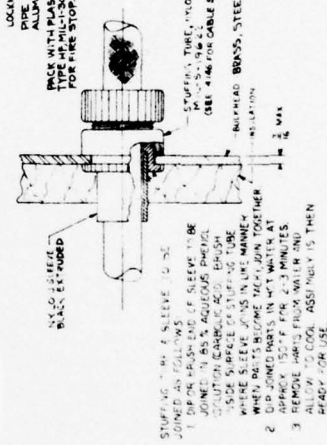


414.3 CABLES THROUGH WATERTIGHT BULKHEADS WITH INSULATION

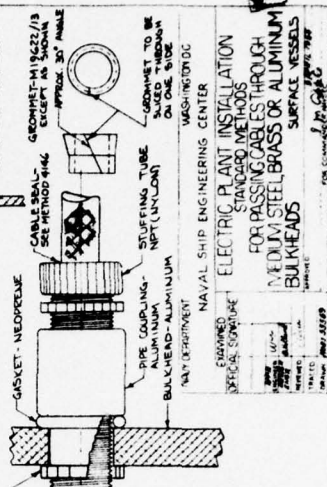


414.3 CABLES THROUGH WATERTIGHT BULKHEADS WITH INSULATION

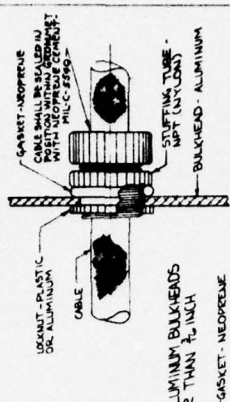
414.4 ALTERNATE TO 414.3 (SEE NOTE 2)



414.7 CABLES THROUGH WATER TIGHT ALUMINUM BULKHEADS WITH THICKNESS GREATER THAN 1/4 INCH



414.6 CABLES THROUGH WATER TIGHT ALUMINUM BULKHEADS WITH THICKNESS 3/16 INCH OR LESS



NOTES

1. PIPES USED IN CONJUNCTION WITH STUFFING TUBES MAY BE OF STEEL, BRASS, OR ALUMINUM. THE FOLLOWING TYPES OF BULKHEADS REQUIRE BOTH SIDES ARE REQUIRED:
 - A. STEEL
 - B. BRASS
 - C. ALUMINUM
2. METHOD 414.6 IS RESTRICTED FOR USE TO NON FLAME LIGHT BULKHEADS OR PARTS OF BULKHEADS WHICH ARE TO BE USED IN STEEL OR ALUMINUM VESSELS.
3. IN METHODS 414.4, 414.6 AND 414.7, APPLY SILICONE RUBBER RTV 793 TO THE GEOMET AS NECESSARY TO PASS THE COMPARTMENT AIR TIGHTNESS TEST.

REVISIONS			
NO.	DATE	DESCRIPTION	BY
1	10/1/51	REVISION 1	WJH
2	10/1/51	REVISION 2	WJH
3	10/1/51	REVISION 3	WJH
4	10/1/51	REVISION 4	WJH
5	10/1/51	REVISION 5	WJH

SECTION 4
SHEET 14

NAVAL SHIP ENGINEERING CENTER
WASHINGTON, D.C.

ELECTRIC PLANT INSTALLATION
STANDARD METHODS
FOR PASSING CABLES THROUGH
MEDIUM STEEL BRASS OR ALUMINUM
BULKHEADS
SURFACE VESSELS

DATE: 10/1/51
BY: WJH

SCALE: 1" = 1'-0"

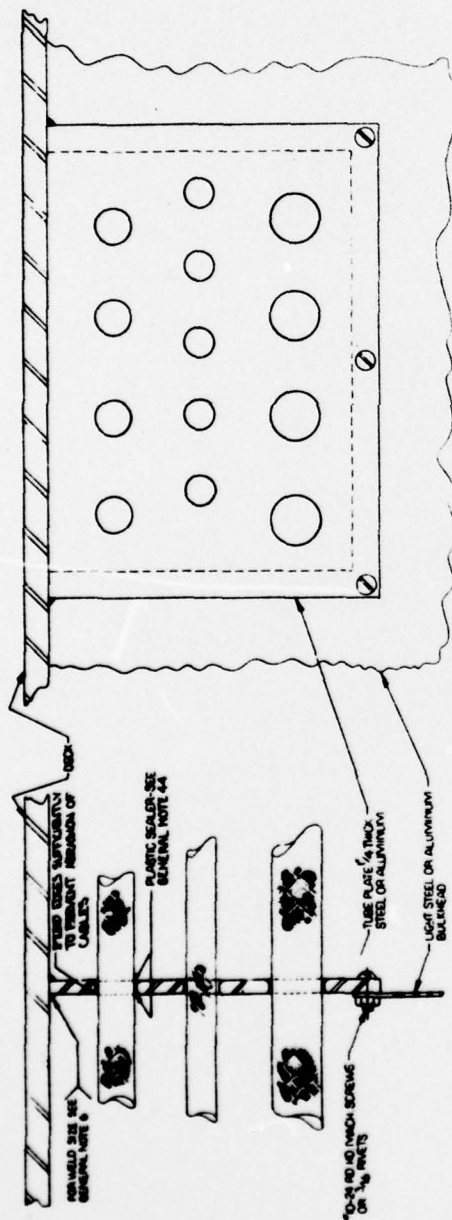
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-73-

CABLES THROUGH NON-WATERTIGHT BULKHEADS OR BEAMS

4211

MULTIPLE ROWS OF CABLES THROUGH LIGHT BULKHEAD
WITH AIR AND FLAME TIGHTNESS REQUIREMENTS



NOTE -
1. MINIMUM SPACING OF TUBES TO BE SUFFICIENT TO PERMIT
SATISFACTORY WELDING

NAVY DEPARTMENT
BUREAU OF SHIPS

ELECTRIC PLANT INSTALLATION
STANDARD METHODS
PASSING MULTIPLE CABLES
THROUGH NON-WATERTIGHT
BULKHEADS AND BEAMS

SECTION 4	SHEET 21
NO. 149000	54202
79980	10
SCALE 3/16"=1'-0"	

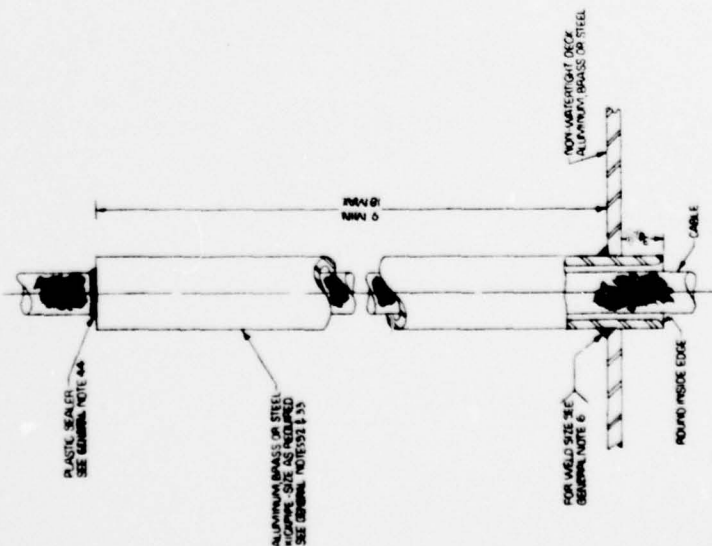
REV. B: ADDED NOTE 1. REVISED METHOD CALL
TO USE 1/2" PLATE (WAS 1/4" PLATE) PERMANENT
REV. C: DELETED NOTE 2. AMENDMENT TO
REV. B: CAN HAVE CABLE IN VIEW 4211. 1/4" AND

REL. B. DELETED CONDUIT BUSHING. 6-11-79 AMF

CABLES THROUGH NONTIGHT DECKS

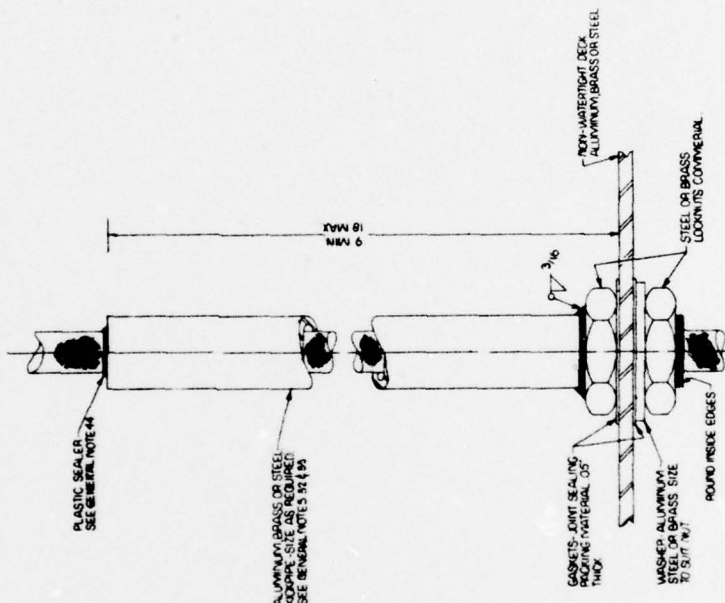
4261

ONE OR TWO SINGLE CABLES
THROUGH NONTIGHT DECKS
WITH KICKPIPE WELDED IN PLACE



4262

ONE OR TWO SINGLE CABLES
THROUGH NONTIGHT DECKS
WITH KICKPIPE SECURED WITH LOOKNUTS
APPLICABLE IN LOCATIONS INACCESSIBLE FOR WELDING



NAVY DEPARTMENT		BUREAU OF SHIPS		WASHINGTON D.C.	
DRAWING		ELECTRIC PLANT INSTALLATION		STANDARD METHODS	
OFFICIAL SIGNATURE		FOR PASSING SINGLE CABLES THROUGH NONTIGHT		ALUMINUM BRASS OR MEDIUM STEEL DECKS	
DESIGNED BY		(SURFACE VESSELS)			
CHECKED BY					
APPROVED BY					
DATE		1979			
SECTION 4		9000		56202	
SHEET 26		73960		B	
				SCALE: 1/2"=1'-0"	

MULTI-CABLE TRANSPORT:
A SYSTEM OF PASSING
CABLES THRU WATER AND NON-WATER TIGHT
BULKHEADS AND DECKS DESIGNED TO SUIT PARTICULAR BULKHEAD
AND DECK WEIGHTS

NOMENCLATURE

THROUGHOUT THIS STANDARD OF ELECTRIC PLANT INSTALLATION DRAWINGS
THE FOLLOWING SHALL PREVAIL

- (A) FRAMES, UNBURNED
- (1) CONSISTS OF THREE BASIC SIZES 1, 2 AND 3, ALL ARE 5/16" WIDE.
 - (2) SIZE 1 IS 4 1/2" HIGH, SIZE 2 IS 10 1/2" HIGH AND SIZE 3 IS 15 1/2" HIGH.
 - (3) (DEPENDS ON WEIGHT OF BURNER OR BURNER) IN STEEL OR IN THICK IN ALUMINUM, ALL ARE 1 1/2" WIDE.
 - (4) THERE ARE FOUR DIFFERENT TYPE FRAMES
 - RG5 - STEEL, FOUR CORNERS WELDED (COMPLETELY CLOSED)
 - RG10 - STEEL, TWO CORNERS WELDED (OPEN IN BOTTOM)
 - RG14 - ALUMINUM, FOUR CORNERS WELDED (COMPLETELY CLOSED)
 - RG40 - ALUMINUM, TWO CORNERS WELDED (OPEN BOTTOM)
 - (5) ALL FRAMES HAVE 1/2" THICK TUBES, THE 1 1/2" FRAME IS IDENTIFIED AS FOLLOWS: ALL RG5, 2, 3, 4 ARE 1/2" THICK.
 - (6) SIZE 2, STEEL, FRAMES WITH FOUR CORNERS WELDED (COMPLETELY CLOSED)

(9) FRAMES

- (8) CONSISTS OF THREE BANC SIZES SUB-MAGNET (A) EACH OF WHICH IS ENCLOSED IN AN ALUMINUM SHEET (B) WHICH IS WELDED TO THE THERMAL INSULATION (C) TO PREVENT AIR LEAKAGE. IN ADDITION TO THE BAND FILLER PLATES ARE EMPLOYED TO SEAL EMPTY SPACES
- (9) BETWEEN FRAME AND BAND
- (10) RIGID AND SOFT BANNED FRAMES ARE COMPLETELY SIZES READY TO BE INSTALLED. THE SOFT BANNED FRAMES HAVE LOWER HALF OF BAND AND FRAME TEMPORARILY TACK WELDED. AT INSTALLATION THIS TACK WELD IS BROKEN, FRAME IS WRAPPED AROUND CABLES,

AND

- (C) VARIOUS ARRANGEMENTS OF FRAMES ARE AVAILABLE IN ALL SIZES AND TYPES. EXAMPLES AND DIMENSIONS ARE SHOWN ON SHEETS 176/177/78.
- (CE) IDENTIFICATION OF VARIOUS ARRANGEMENTS ARE MADE BY THE FOLLOWING EXAMPLES

- TYPE SIZE NUMBER OF MATL
OPENINGS IN TANDEM
SINGLE OR DOUBLE WALL RANDED OR UNBANDDED MUST BE SPECIFIED

(d) COMMENTS

- (6) STAINLESS STEEL $\frac{3}{16}$ "-10 THREAD WHEN TIGHTENED SEATS THE COMPRESSION PLATE FARTHER DOWN INTO THE TRANSIT FRAME

24

- (1) EITHER STEEL OR ALUMINUM NORMALLY PLACED BETWEEN EVERY OTHER ROW OF INSERT BLOCKS KEEPING THEM POSITIONED IN THE TRANSIT FRAME

53660576

- (b) EITHER SET IN OR ON THE ENDPACKING, AS THE CASE MAY BE, SO THAT THE INSERT BLOCKS SO THAT THE ENDPACKING CAN BE INSERTED IN THE TRANSIT FRAME
- (c) END PACKING - STANDARD

(A) COM
END PAGE

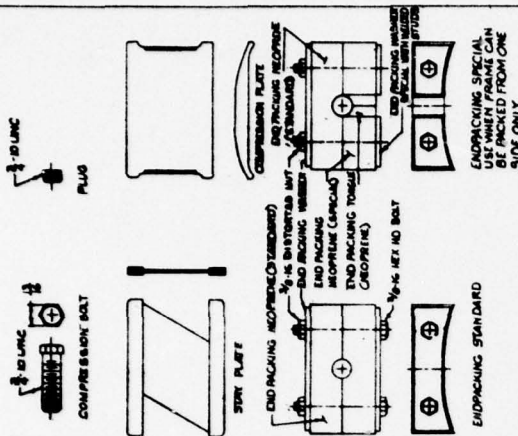
- (2) ASSEMBLY, WHICH CONSISTS OF TWO NEOPRENE ELASTOMER BLOCKS AND TWO END PACKING WASHERS HELD TOGETHER BY TWO 3/8" BOLTS AND HEX NUTS, WASHERS, NUTS AND BOLTS ARE STEEL. CADMIUM PLATED FOR NON MAGNETIC APPLICATION. STAINLESS STEEL IS USED.

AGS (17)

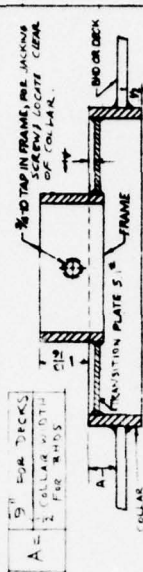
- BE PACKED FROM ONE SIDE
(2) ASSEMBLY WHICH CONSISTS OF FOUR NEOPRENE ELASTOMER
PIECES, ONE END PACKING WASHER, TWO END PACKING
WASHERS SPECIAL AND TWO 1/8 HEX NUTS ALL ARE STEEL
CADDIUM PLATED FOR NON-MAGNETIC APPLICATIONS
STAINLESS STEEL IS USED

NOMENCLATURE

- (N) TWIN HALF BLOCKS ARE SPECIALLY FORMULATED OF A NEOPRENE ELASTOMER WITH A CENTERED SPIKE-CIRCULAR GROOVE WHEN PACKING AROUND A CABLE THESE BLOCKS FORM A SINGLE BLOCK WITH A TIGHT FIT BASIC CABLE SIZES ARE SHOWN ON SHEET 77
- (L) SOLID BLOCKS ARE SPECIALLY FORMULATED OF A NEOPRENE ELASTOMER AND ARE USED AS PILEDS OR SPARE PROVISIONS FOR ADDITION OF FUTURE CABLE SIZES ARE SHOWN ON SHEET 77
- (M) FILLING (M) THIS MATERIAL AN INSERT BLOCKS USED TO REACH THICKNESSES OF 1/8 OR 1/4 INCHES CAUSED BY THE PRESENCE OF DIFFERENT SIZE BLOCKS IN THE SAME FRAME EMPLOYED TO INCREASE THE PRESSURE IN THE TRANSIT FRAME WHEN EXCEPTIONALLY SOFT CABLES ARE USED THESE FILLING ARE AVAILABLE IN TWO SIZES 24-36 OR 12-1/4 INCH CASE SIZE 77) SERATIONS HAVE BEEN PROVIDED TO PERMIT THE FILLING OF THE REQUIRED LENGTH EXAMPLE 6-1/4 8-1/4 ETC
- (O) INSERT BLOCK LUBRICANT USED WHEN PACKING TRANSIT FRAME IT ALLOWS THE BLOCKS TO SLIDE EASILY ONE AGAINST OTHER WHEN PACKING AND COMPRESSING THEM AROUND CABLES
- (P) LIQUID SILICONE GREASE APPLIED TO CABLE SIZE OF EACH GAUGE BLOCK UPON COMPRESSION THIS PROVIDES A SEAL BETWEEN THE ADJACENT CABLES AND ITS IMMEDIATE INNER SHEATH
- (Q) COIL WINDING TO BE IN ACCORDANCE WITH MIL-N-25027C MATERIALS 605 PER MIL 5-257



ENDPACKING STANDARD

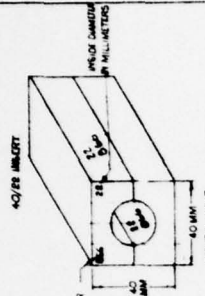


TYPICAL SECTION THRU BANDED FRAME
SHOWING LOCATION OF FRAME / TRANSITION PLATE
PLATE WHEN WELDED IN COLLAR.

NAVY DEPARTMENT NAVAL SHIP ENGINEERING CENTER		WASHINGTON D.C.	
EXAMINED		ELECTRIC PLANT INSTALLATION	
TECHNICAL INSPECTION		STANDARD METHODS	
		NOMENCLATURE	
		FOR MULTI-CABLE TRANSIT	
APPROVED		DATE 11-28-70 BY [Signature] COMMANDER MANSC	
SECTION 4		REV	
SHEET 7/10		9000 \$6202 7398d B	

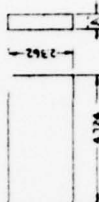
CABLE INFORMATION AND ASSIGNMENT FOR MULTI-CABLE TRANSIT INSERT BLOCKS[illegible][illegible]

INCHES	1/4"	3/8"	1/2"	5/8"	3/4"	7/8"	1"	1 1/8"	1 1/4"	1 1/2"
1/4"	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25
3/8"	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50
1/2"	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75
5/8"	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00
3/4"	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25
7/8"	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50
1"	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75
1 1/8"	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00
1 1/4"	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25
1 1/2"	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25	5.50



FILE 1045	"A" DIM
24 x 5/0	196
12 x 10/0	393

FIGURE NO. 6



PAGES	A DIM
15/0	990
20/0	787
30/0	1161

[illegible]

NOTES

- (1) LIFT COMPRESSION PLATE CLEAR OF STAY PLATE NO 2 ADD FINAL ROW
- (2) OF SIX 20/0 SPARES, LOWER COMPRESSION PLATE TO THIS LEVEL
- (3) TIGHTEN COMPRESSION BOLT DOWN ON COMPRESSION PLATE TO COMPRESS ENTIRE CONTENTS
- (4) OF FRAME AND PROVIDE JUST ENOUGH CLEARANCE TO INSERT END PACKING ASSEMBLY
- (5) APPLY A CARTRIDGE JOINT TO THE CARTRIDGE JOINT TO REMOVE THE EFFECT OF BOND PACKING
- (6) THE COMPRESSION BOLT ASSEMBLY IS TO BE INSTALLED IN A STRUCTURE IN SUCH A MANNER THAT THE COMPRESSION BOLT IS LOCATED ON THE BOTTOM
- (7) EVENLY UNTIL END PACKING INSERT MATERIAL EXPANDS IN THE CAVITY
- (8) AND THERE IS A SLIGHT ROLL OF THE MATERIAL AROUND THE END
- (9) PACKING METAL WASHERS BACK OFF COMPRESSION BOLT APPROX
- (10) 1/8 OF A TURN, PACKING IS NOW COMPLETE
- (11) A MANNER THAT THE COMPRESSION BOLT IS LOCATED ON THE BOTTOM
- (12) PACKING PROCEDURE IS THE SAME EXCEPT
- (13) (A) THE COMPRESSION PLATE IS INSTALLED FIRST
- (14) CABLES BEING PACKED FIRST
- (15) TO ADD A NEW CABLE TO A PACKED FRAME LOOSEN THE 3/4 IN. HEX NUTS
- (16) UNTIL END PACKING INSERT MATERIAL IS LOOSE, REMOVE INSERT
- (17) MATERIAL FROM FRAME, LOOSEN COMPRESSION BOLT AND LIFT COMPRESSION
- (18) PLATE CLEAR OF TOP SIX 20/0 SPARES REMOVE THESE INSERTS REMOVE
- (19) COMPRESSION PLATE AND FULL ACCESS TO THE INSERT BLOCKS AND CABLE
- (20) IS AVAILABLE
- (21) WORK FROM SHIP
- (22) ALL WELDING AND INSPECTION TO BE IN ACCORDANCE WITH NAVY SHIPS
- (23) 0900-000-1000
- (24) BALL PAINTING TO BE DONE IN ACCORDANCE WITH PLAN TYPE 308-248-0004
- (25) THE STRUCTURAL REINFORCEMENT SHOWN ON THIS PLAN DOES NOT
- (26) APPLY TO FLIGHT DECK BENTS, FLIGHT DECK SUPPORT STRUCTURES OR
- (27) OTHER SIMILAR TYPE STRUCTURE ON OTHER SHIPS SUCH CABLES MUST
- (28) BE INDIVIDUALLY RESOLVED WITH STRUCTURAL DESIGN
- (29) MATERIAL OF FB REINFORCEMENT IS TO BE SIMILAR TO MATERIAL OF BND, DECK
- (30) OR HIER BOX STRUCTURE
- (31) FROM DESIGN DATA SHEET D05B01, REINFORCEMENT
- (32) OF OPENINGS IN STRUCTURE OF SURFACE SHIPS OTHER THAN IN PROTECTIVE PLATING
- (33) TO PERMIT INSTALLATION OF MULTI-CABLE TRANSIT FRAME (FAMETIC) RESULTS OF
- (34) NELSON ELECTRIC IN WATERTIGHT DECKS AND BND'S OF SURFACE SHIPS
- (35) 18 FILL WELD REINFORCEMENT FOR TBVI WELD JOINT SHALL BE 1/8" FOR
- (36) BATING UP TO 15" AND 1/4" FOR BATING ABOVE 15"
- (37) 13 THE BND'S AND DECKS WHICH ARE CONSIDERED TO BE LONGITUDINAL STRENGTH
- (38) MEMBERS ARE DEFINED IN NAVY SHIPS DESIGN DATA SHEET D05B01 AS
- (39) STRENGTH DECK, INNER BOTTOM, AND THEIR ASSOCIATED LONG FRAMING,
- (40) OTHER THAN THE BND'S AND DECKS WHICH ARE CONSIDERED TO BE LONGITUDINAL
- (41) STRENGTH MEMBERS IF THERE IS DIFFICULTY IN DEFINITION CONSULT WITH STRUCTURAL
- (42) DESIGN
- (43) CARE SHOULD BE TAKEN WHILE INSTALLING CABLE TRANSIT DEVICE TO INSURE
- (44) THAT ALL OF ITS COAMING PROTRUDES THRU BND SUFFICIENTLY TO WELD
- (45) IN PLACE
- (46) 15 IT IS MANDATORY TO MAINTAIN A MINIMUM OF 1/4" FROM BND TO BOLT HOLE
- (47) CENTER FOR WRENCH CLEARANCE ALSO LEAVE 4" CLEARANCE TO ALLOW FOR
- (48) INSTALLATION OF COMPRESSION BOLT FROM BOLT HOLE SIDE OF CTD TO
- (49) TO ANY STRUCTURE
- (50) 16 RISER BOX TO BE ATTACHED TO BND OF 7/8" RT OR HANDED IF BND IS LESS THAN
- (51) 18" ADVANCE THE RISER BOX INSTALLATION, INSTALL A BACK PLATE OF 10/8"
- (52) 17 AFTER INSTALLATION IS COMPLETE ENTIRE DEVICE MAY BE PAINTED TO SUIT
- (53) SURROUNDING STRUCTURE IN ACCORDANCE WITH THE GENERAL SPECIFICATIONS
- (54) FOR BUILDING SHIPS FOR THE U.S. NAVY

RCS AND RCA CABLE TRANSIT DEVICES

1. MULTI-CABLE TRANSIT IS A MODULAR SYSTEM THAT UTILIZES STANDARD UNITS AND DIMENSIONS TO ALLOW MAXIMUM FLEXIBILITY AND COMPATIBILITY WITH VARIOUS NUMBERS AND SIZES OF CABLES. FINAL SIZED UNITS WILL PROVIDE WATERTIGHT, AIRTIGHT AND FIREPROOF BULKHEAD OR DECK PENETRATIONS.
2. PULL ALL CABLES THRU CABLE TRANSIT DEVICE BEARING IN MIND CABLE SHALL BE SECURED TO THE TRANSIT DEVICE BY THE NEAREST CABLE WANCHER. IS
3. MINIMUM FROM BULKHEAD. CABLES RUNNING UP A BULKHEAD AND THRU A TRANSIT DEVICE MUST HAVE ITS FULL BENDING RADIUS OUTSIDE OF THE DEVICE. WHILE IN THE PROCESS OF PULLING CABLES IT IS INTERPRETIVE THAT A REASONABLE AMOUNT OF SLACK SHOULD BE LEFT TO FACILITATE MOVEMENT OF CABLES WITHIN THE TRANSIT DEVICE. ALSO, THE TRANSIT DEVICE IS TO BE SECURED TO THE BULKHEAD OR DECK BY THE NEAREST CABLE WANCHER. IS
4. THE TRANSIT DEVICE SHALL BE INSTALLED ON TOP OF THE TRANSIT DEVICE. THE TRANSIT DEVICE SHALL BE PULLED PRIOR TO INSTALLING INSERT BLOCKS
5. AFTER PULLING ALL CABLES THROUGH A PARTICULAR CABLE TRANSIT DEVICE IT CAN BE PACKED. FIRST APPLY A LIGHT COAT OF GREASE TO THE INSIDE PORTION OF THE FRAME AND THE CURVED SURFACE OF THE COMPRESSION PLATE WHEN PACKING ARMORED CABLE, APPLY GENERAL ELECTRIC'S HTV-112 SEALER ON THE SURFACE OF EACH BLOCK THAT CONTACTS THE CABLE (A 1/8" BEAD EVERY 1/2" AROUND THE CIRCUMFERENCE). EACH FRAME MUST BE LAID OUT (GROOVED) SHOWING SOLID BLOCKS (USED AS SPARES) AND CABLE ASSIGNMENTS PRIOR TO PACKING. AN APPROVED RGS-4 FRAME WITH INSTRUCTIONS FOR PACKING IS SHOWN BELOW (SCALE 1/4")

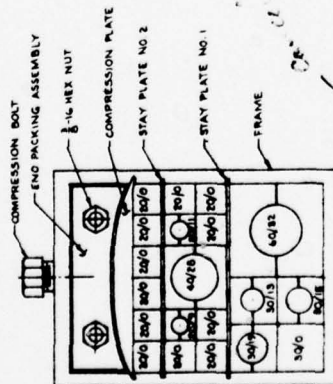


FIGURE NO 7

- (A) SELECT INSERT BLOCKS AND SPARES FROM SHEET 16/ AND PREPARE AS ABOVE (LUBRICANT AND SEALER WHERE REQUIRED)
- (B) STARTING WITH THE HEAVIEST CABLE PLACE THE LOWER HALF OF THE 60/32 INSERT BLOCK UNDER THE CABLE IN THE FRAME. ADD THE UPPER HALF OF THE 60/32 AND THE 30/15 PLATE LOWER HALF OF 30/15 AND 30/15 UNDER CABLE THEN ADD UPPER HALVES, ALONGS THE TOP OF THESE ADD STAY PLATE NO 1
- (C) ON TOP OF THE STAY PLATE PLACE FOUR 20/0 SPARES AND THE LOWER HALF OF THE 40/32 UNDER ITS CABLE IN THE NEXT HIGHER ROW PLACE THE 40/32 UNDER ITS CABLE IN THE NEXT HIGHER ROW. ADD THEIR RESPECTIVE CABLES THEN ADD UPPER HALVES OF 40/32, 20/15 AND 20/8 ON TOP OF THESE ADD STAY PLATE NO 2
- (D) ADD COMPRESSION PLATE TO THE FRAME

NAVY DEPARTMENT NAVAL SHIP ENGINEERING CENTER		WASHINGTON DC
EXAMINED ELECTRIC PLANT INSTALLATION		DATE 1/1/72
STANDARD METHODS		FOR MULTI-CABLE TRANSITS
NOTES		
APPROVED	DATE 1/1/72	
SECTION 4	SHEET 172	
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MULTI-CABLE TRANSIT FRAME IN BULKHEADS

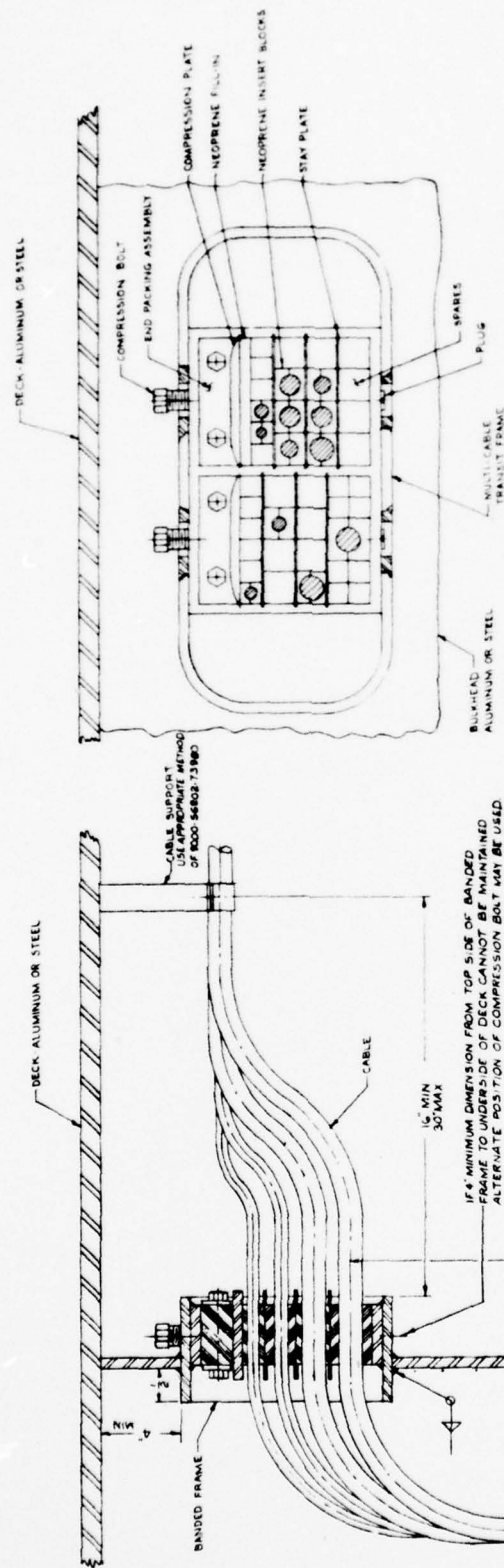


FIGURE NO 9

NOTE: MULTI-CABLE TRANSIT FRAMES ARE AVAILABLE IN VARIOUS SIZES AND ARRANGEMENTS SHOWN IN TWO SEAS TRANSIT

FIGURE NO 8

NAVY DEPARTMENT		WASHINGTON, D.C.	
NAVAL SHIP ENGINEERING CENTER			
ELECTRIC PLANT INSTALLATION			
STANDARD METHODS FOR PASSING CABLES THROUGH BULKHEADS USING MULTI-CABLE TRANSIT FRAME			
DESIGNED BY	APPROVED BY	DATE	REVISION
1000-56202-73980	1000-56202-73980	1000-56202-73980	1000-56202-73980
SECTION 4		SHEET 173	
NAVY		1000-56202-73980 A	

REVIEWS

1. **WEEK NOTES** 1968, 84, 1968-1970S AND 1970-1971S
2. **FIELD NOTES** 22-26, 8/12 WAS SHORT N. - 8-8-69
3. **REVISED NOTES** 13-15-69
4. **REVISED NOTES** 17-19-69
5. **REVISED NOTES** 21-23-69
6. **NOTES** 24-25-69
7. **REVISED NOTES** 27-29-69
8. **REVISED NOTES** 31-33-69
9. **REVISED NOTES** 35-37-69
10. **REVISED NOTES** 39-41-69
11. **REVISED NOTES** 43-45-69
12. **REVISED NOTES** 47-49-69
13. **REVISED NOTES** 51-53-69
14. **REVISED NOTES** 55-57-69
15. **REVISED NOTES** 59-61-69
16. **REVISED NOTES** 63-65-69
17. **REVISED NOTES** 67-69-69
18. **REVISED NOTES** 71-73-69
19. **REVISED NOTES** 75-77-69
20. **REVISED NOTES** 79-81-69
21. **REVISED NOTES** 83-85-69
22. **REVISED NOTES** 87-89-69
23. **REVISED NOTES** 91-93-69
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27. **REVISED NOTES** 107-109-69
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151. **REVISED NOTES** 603-605-69
152. **REVISED NOTES** 607-609-69
153. **REVISED NOTES** 611-613-69
154. **REVISED NOTES** 615-617-69
155. **REVISED NOTES** 619-621-69
156. **REVISED NOTES** 623-625-69
157. **REVISED NOTES** 627-629-69
158. **REVISED NOTES** 631-633-69
159. **REVISED NOTES** 635-637-69
160. **REVISED NOTES** 639-641-69
161. **REVISED NOTES** 643-645-69
162. **REVISED NOTES** 647

GENERAL -

1- THE ELECTRIC PLANT INSTALLATION GENERAL REQUIREMENTS, SHALL BE IN ACCORDANCE WITH FUNCTIONAL ARRANGEMENT S. SHOWN HEREIN.

2- ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED ON THE INDIVIDUAL SHEET.

WELDED ATTACHMENTS

6. SEE SHEET G, NOTE 13"
6A. FOR PRECAST APPLICATIONS, ALL WELDING
SHALL BE IN ACCORDANCE WITH THE REQUIREMENTS OF
AISC 360-10.
6B. COLLAR STUDS SHALL BE IN ACCORDANCE WITH
SPCC 51.5-10.109

THREADED ATTACHMENTS
 ALL THREADED PARTS SHALL BE AMERICAN NATIONAL FORM
 COARSE SERIES CLASS 2 UNLESS OTHERWISE SPECIFIED. THREADED
 FASTENINGS SHALL BE AS SPECIFIED IN THE HANDBOOK H-28
 IS BOLTS, STEEL NUTS, ETC SHALL BE TREATED OR UNOIL-DRAWN
 BEFORE BEING USED TO THE JOINTS STRUCTURE
 6 POINTS BOLTS NUTS MACHINE SCREWS AND PLAT
 WASHERS SHALL BE OF THE BEST COMMERCIAL GRADE OF THE
 MATERIAL SPECIFIED
 UNLESS THE USE OF THE NEW-ALLOY BOLTS, SPECIFIED, NO LONGER
 THREADED MACHINE SCREWS OF THE SAME SIZE MAY BE USED

MOUNTING CLEARANCES

ALL ELECTRICAL CABLES, PIPES, RAILS, APPLIANCES, ETC., SHALL BE MOUNTED IN SUCH A MANNER THAT THEY DO NOT COME INTO DIRECT CONTACT WITH THE OUTER SHEATH OF THE SHIELD. A 2-INCH MINIMUM CLEARANCE SHALL BE MAINTAINED FOR INSPECTION AND PAINTING.

THE MOUNTING OF ELECTRICAL EQUIPMENT ON PILLS OR HEADS SUBJECT TO CORROSION, SUCH AS OUTER SHEATHS OF CABLES, SHALL BE MADE IN SUCH A MANNER THAT THE EQUIPMENT, IF NO OTHER LOCATION IS FEASIBLE, THE EQUIPMENT SHALL BE MOUNTED AT LEAST TWO INCHES CLEAR OF SUCH SURFACES. ALSO, CABLES SHALL NOT BE MOUNTED IN SUCH A MANNER THAT THEY COME INTO DIRECT CONTACT WITH SUCH SURFACES, BUT SHALL USE ONE OF THE NEXT LOCATION METHODS WHEN SUCH SURFACES ARE BLASTED OR RICH IN COPPER, IRON, AND CARBON.

CABLE SUPPORTS (SEE SHEET 'G')

29 ELECTRICAL DISTRIBUTION AND MOUNTING ELEMENTS AND APPLIANCES SHALL BE INSTALLED AS SHOWN HEREON.

31-AMPHI CABLES ENTIRE CITIES AND MIXTURES A
MIXTURE OF 2 MIXTURES OF SLACK CABLE SHALL BE PROVIDED
FOR THE CABLES TO BE USED IN THE CABLES. THE CABLES
SHALL BE USED IN THE CABLES TO BE USED IN THE CABLES.
WHILE THIS SLACK IS NOT NECESSARY FOR CABLES THE
CONDUCTORS OF WHICH HAVE BEEN USED IN THE CABLES
CABLES TO BE USED IN THE CABLES TO BE USED IN THE CABLES.
TO MAKE CABLES TO BE USED IN THE CABLES TO BE USED IN THE CABLES.
31-AMPHI CABLES ENTIRE CITIES AND MIXTURES A
MIXTURE OF 2 MIXTURES OF SLACK CABLE SHALL BE PROVIDED
FOR THE CABLES TO BE USED IN THE CABLES. THE CABLES
SHALL BE USED IN THE CABLES TO BE USED IN THE CABLES.
WHILE THIS SLACK IS NOT NECESSARY FOR CABLES THE
CONDUCTORS OF WHICH HAVE BEEN USED IN THE CABLES
CABLES TO BE USED IN THE CABLES TO BE USED IN THE CABLES.
TO MAKE CABLES TO BE USED IN THE CABLES TO BE USED IN THE CABLES.

3.5 BOX CONNECTORS SHALL BE THE TYPE WITHOUT RETAINING LIPS AND WITHOUT ENLARGEMENT FOR CONDUIT OR "BA" REMOVED "STRAIGHT DUPLX." BOX CONNECTORS MAY BE USED FOR CABLE ENTRANCES, HOWEVER, THE CABLES SHALL BE THE TYPE HAVING INSULATED COVERED CONDUCTORS. DUPLX CONNECTORS ARE NOT TO BE USED FOR CABLES HAVING WEAR SILICON COVERED FACTORY CONNECTORS.

ALUMINUM STRUCTURE MOUNTING
36-ELCTICAL FITTINGS HAVING BRASS ENCLOSURES
WHEN INSTALLED ON ALUMINUM STRUCTURE, SHALL BE
MOUNTED IN ACCORDANCE WITH METHODS SHOWN HEREIN
TO PREVENT GALVANIC ACTION.

(B) WELDED ATTACHMENTS (CONTINUED FROM LEFT)

- (1) BALLISTIC STRIKE AREA
- (2) THREAT DEFENSE SYSTEM BULKHEAD
- (3) SMALL PLATING

THE CLEARANCE SHALL BE IN THE RAMPING

SEE NOTE FOR TREATMENT OF CRACKS WHEN SINGLE FILLET WELDS ARE USED IN HIGH STRESS AREAS.

ALL SURFACES MUST BE FINISHED TO A MINIMUM OF 60 GRADE SURFACE FINISH UNLESS A SPECIFIED BETTER CABLE CLEARANCE IS CALLED OUT BY DRAWING. EXCEPT FOR FOLLOWING STRUCTURE WHICH SHALL BE DRILLED OR MACHINED TO THE SPECIFICATION AND NOT CUT TO SIZE DURING FABRICATION:

- (A) BALLISTIC STRUCTURE

(4) UPPERMOST STRENGTH DECK
SEE SECTION 4 SHEETS 11 & 14

CABLE STRUTTING TUBES AND BOLT CONNECTIONS
36-GAUGE ALUMINUM BRACKETS SHALL BE STANDARD PER SIZE.
THE INSIDE DIAMETER SHALL BE CHAMFERED AND BOLTS FASTENING ON THE INSIDE WALL SHALL BE WEDGED TO PREVENT CHIPPING OF CABLE.
34-STRAIGHT TUBE PACKING SHALL BE IN ACCORDANCE WITH SPECIFICATIONS EITHER THE PREPARED (COIL) CLASS 2 OR BULK CLASS 1. WHEN BULK PACKING IS USED THE FIRST AND LAST TUBES SHALL BE PART A (HARD) AND THE INTERMEDIATE TUBES SHALL BE PART B (SOFT) OF CLASS 1.

3.5 BOX CONNECTORS SHALL BE THE TYPE WITHOUT RETAINING LIPS AND WITHOUT ENLARGEMENT FOR CONDUIT OR "BA" REMOVED "STRAIGHT DUPLX." BOX CONNECTORS MAY BE USED FOR CABLE ENTRANCES, HOWEVER, THE CABLES SHALL BE THE TYPE HAVING INSULATED COVERED CONDUCTORS. DUPLX CONNECTORS ARE NOT TO BE USED FOR CABLES HAVING WEAR SILICON COVERED FACTORY CONNECTORS.

BUREAU OF SHIPS		ELECTRIC PLANT INSTALLATION STANDARD ML-1005		GENERAL NOTES	
SECTION I		SHEET 1		SHEET 2	

13.5 - STUFFING TUBES, CHAFERS, NIPPLES & KICKERS DESIGNED TO BE INSTALLED IN A CLEARANCE HOLE & PASS COMPLETELY THROUGH DECKS & BULKHEADS. SHALL IN GENERAL, BE WELDED ON ONE SIDE OF THE DECK OR BULKHEAD, EXCEPT THAT IN THE FOLLOWING APPLICATIONS, THEY SHALL BE FILLET WELDED ON BOTH SIDES OF THE STRUCTURE :

(CONTINUED IN NEXT COLUMN)

-82-

GENERAL NOTES (CONTINUED) PROCEDURES FOR CABLE INSTALLATIONS ON NAVAL VESSELS

REVISIONS
REVISION NO. 1
REVISION DATE 12/84
REVISION NOTES 1 AND 2

1. CABLE INSTALLATION SHALL BE IN ACCORDANCE WITH METHODS SHOWN HEREIN.
2. THE CABLE SUPPORT METHODS SHOWN HEREIN ARE TO BE USED ONLY AS A GUIDE LINE. THE DEVELOPMENT OF A READY SUPPORTING SYSTEM, CAPABLE OF SATISFACTORY CABLE SUPPORT, USE OF DETAILED AND IDENTIFIABLE ITEMS HEREIN IS NOT REQUIRED. ANY CABLE SUPPORT METHOD, DEVICE OR SYSTEM CAN BE USED PROVIDED THE FOLLOWING IS ACHIEVED:
 - a. RESISTANCE TO SHOCK MIL-S-901
 - b. RESISTANCE TO VIBRATION MIL-STD-167
 - c. MINIMUM WEIGHT
 - d. MINIMUM COST
 - e. MAXIMUM USE OF INDUSTRIAL MILL AND COMMERCIAL NON-PROFESSIONAL METHODS FOR MINIMUM SURVEILLANCE DURING INSTALLATION.
3. MINIMUM MAINTENANCE ON CABLE SUPPORTING SYSTEMS.
 - a. FACILITATE CABLEING PROCEDURES.
 - b. CONVENIENCE OF SERVICE ON CABLEING SYSTEM.
 - c. PREPROOF UNLESS EXCEPTED IN SPECIFIC AREAS SUCH AS WOOD SHIPS.
 - d. MATERIAL USED IS NON TOXIC UNDER ALL CONDITIONS OF PROTECTIONS CORRUPT, ITEMS, ETC., DANGEROUS TO PERSONNEL.
 - e. SHALL BE SO DESIGNED TO PERMIT REPAIR WITH LOCAL MARKET TENDS IT IS NOT ANTICIPATED THAT EXTENSIVE BACKUP STOCKS BE SUPPLIED FOR ITEM OR ITEM REPLACEMENT.
 - f. COMPATIBLE WITH NON-DAMAGING TO CABLES.
 - g. (NOTE: USE OF INSULATING SPACER BACKS IS MANUFACTORY FOR PROPULSION CABLES TO PREVENT BRANCHING.)
4. ALL CABLE SUPPORTING ARRANGEMENTS SHALL BE TESTED FOR RESISTANCE TO SHOCK AND VIBRATION. DEFORMATION TO SUPPORTING MEMBERS AND RETAINING MEMBERS IS SATISFACTORY PROVIDED CABLES ARE PREVENTED FROM BECOMING WHIPS OR MISSILES AND RETAINERS RACKS AND SUPPORTS DO NOT BECOME MISSILES. SHOCK AND VIBRATION TESTS SHALL BE CONDUCTED AT A RECOMMENDED SPEED. NO MECHANICAL IMPACT SHALL OCCUR CONCOMITANT WITH SPECIFIC AREAS OF THE TEST. REPORT, CERTIFIED BY THE CONTRACTOR INSPECTOR ATTENDING THE TEST, SHALL BE FORWARDED TO THE ATTENTION NAVSHIPS/NAVSPEC, SEC 617E. COPIES SHALL ALSO BE FURNISHED PURCHASING ACTIVITIES UPON REQUEST. THESE TESTS SHALL BE CONDUCTED ANNUALLY, IF RATE OF SALES EXCEEDS AN EXCESS OF THIS TIME FRAME. IF SUCH, THEN TESTS SHALL BE CONDUCTED FOR EACH YEAR. MATERIAL IS NOT SATISFACTORY UNLESS IT WAS SUCCESSFULLY

3. PASSED THESE TESTS. SHOCK TESTS SHALL BE IN ACCORDANCE WITH SPEC MIL-S-901, AND VIBRATION TESTS SHALL BE IN ACCORDANCE WITH SPEC MIL-STD-167. CABLE SUPPORTING DEVICES SHALL BE ARRANGED FOR TESTING AS FOLLOWS:
 - a. CABLE SUPPORT
 - (1) IF MULTIPLE CABLE RACKS ARE BEING TESTED FOR SHOCK AND VIBRATION AS FULLY LOADED, A MINIMUM OF 3 SUPPORTING STATIONS WITH 32" OR 4" SPACING SHALL BE PROVIDED. THE MAXIMUM NUMBER OF THE LARGEST CABLES THAT CAN BE ACCOMMODATED ON THESE RACKS SHALL BE APPLIED. CABLE OVERHANG AT EACH END SHALL BE 4" OR 1/2 THE DISTANCE BETWEEN SUPPORTS.
 - (2) TICS OF MULTIPLE CABLE RACKS AND SUPPORTING DEVICES SHALL BE TESTED TO THE SAME CRITERIA AS TO BE TESTED FOR VIBRATION. THE SAME CRITERIA SHALL BE TESTED FOR VIBRATION. A DUPLICATE OF THE ASSEMBLY PROPOSED FOR SHIPBOARD INSTALLATION WITH A MINIMUM OF 3 SUPPORTING STATIONS WITH 32" OR 4" SPACING SHALL BE PROVIDED. THE MAXIMUM NUMBER OF THE LARGEST CABLES THAT CAN BE ACCOMMODATED ON THESE RACKS SHALL BE APPLIED. CABLE OVERHANG AT EACH END SHALL BE 4" OR 1/2 THE DISTANCE BETWEEN SUPPORTS.
 - b. SINGLE CABLE SUPPORTS
 - (1) ALL SINGLE CABLE SUPPORTS INCLUDING THOSE SUPPORTING TO FED SPEC RE-5750 SHALL BE TESTED. THESE SHALL BE ARRANGED USING A MAXIMUM OF 3 SUPPORTING STATIONS. SPACING 32" OR 4" APART. CABLE OVERHANG SHALL BE 4" OR 1/2 THE DISTANCE BETWEEN SUPPORTS. MAXIMUM 32" OR 4" SPACING SHALL BE PROVIDED WITH THESE SINGLE CABLE SUPPORTS.
 - (2) TWO, THREE OR FOUR CABLES SUPPORTED AS SHOWN ON SHEET 159 (SECTION 2) OF THE DRAWING SHALL BE TESTED. STRAITS SHALL BE ARRANGED FOR TEST IN A MANNER SIMILAR TO THAT FOR SINGLE CABLES.
 - (3) A SINGLE ROW OF CABLES SHALL BE ARRANGED AS DESCRIBED FOR MULTIPLE CABLE RACKS.
 - c. CABLE RETENTION
 - (1) DEVICES FOR CABLE RETENTION ARE NOT REQUIRED ON HORIZONTAL CABLE SUPPORTS IN WET SPACES. RETENTION OF CABLE ON OVERHEAD SUPPORTS IN WET SPACES IS REQUIRED. THIS CAN BE ACCOMPLISHED BY THE USE OF RETAINERS SUCH AS CANTOUR STRAPS OR SOFT RUN PLAT. BARS BENT OVER THE CABLES, MINI-CONTOUR STRAPS OR SUPPORT RETAINERS. ON CABLE RACKS IN WHICH THE CABLE IS VERTICAL OR ON CABLE RACKS IN WHICH THE CABLE IS VERTICAL, CABLE RETENTION IS NOT REQUIRED. SINGLE ROW CABLES WOULD BE REQUIRED TO BE RETAINED. CABLES WOULD BE SUBJECTED TO PHYSICAL FORCES AS SHOWN ON SHEETS 159 AND 167 (SECTION 2). RETAINERS ARE REQ. REQ.

5. SPACING OF STEEL AND ALUMINUM CABLE SUPPORTS SHALL BE 32 INCHES EXCEPT AS FOLLOWS:
 - (1) THE SPACING OF HANDS SHALL BE 2 INCHES TO REDUCE CABLE SAG IN CABLE RACKS WHEN HEADROOM CLEARANCE UNDER THE CABLE RACKS BEHIND INSTALLATION OF CABLES IS 2 FT OR LESS (2' 0" MINIMUM).
 - (2) CABLES SUPPORTED ON TIE TYPE ALUMINUM RACKS, WHEN USED IN WET SPACES, SHALL BE 32 INCHES. AND THE NUMBER OF TIES SHALL BE LIMITED TO 1 PER INCH.
 - (3) THE SPACING OF HANGER SUPPORTS FOR SINGLE CABLES OR SINGLE ROW OF CABLES SHALL IN GENERAL BE 32 INCHES BUT MAY BE ADJUSTED BETWEEN 24 AND 40 INCHES AS NECESSARY TO SUIT PART CULAR SHIP CONDITIONS.
 6. A MAXIMUM OF FIVE ROWS OF CABLES MAY BE SUPPORTED FROM AN OVERHEAD DECK IN ONE CABLE RACK EXCEPT AS NOTED IN A NOTE.
 7. A MAXIMUM OF TWO ROWS OF CABLES MAY BE SUPPORTED FROM BULKHEADS.
 8. CABLE RACKS SHALL BE SUPPORTED IN MAIN CABLEWAYS IN MAIN CABLEWAYS AND BULKHEADS.
 9. CABLE WELD JOINTS EXPOSED ON HORIZONTAL CABLE RUNS COMPARED WITHIN WET SPACES SHALL BE SUPPORTED IN STRUCTURE (THE CABLE SUPPORT BEING HORIZONTAL) NOT REQUIRED.
 10. DOUBLE RACKING OF CABLES IS NOT APPROVED EXCEPT IN SPECIAL CASES AS SHOWN HEREIN.
 11. SACKING PLATES ARE NOT REQUIRED FOR TIE TYPE SUPPORT EXCEPT THAT WHEN SACKING ARE 1/2" THICK OR LESS, SACKING RUN IS OVER 4" IN WIDTH SACKING WASHERS SHALL BE USED.
 12. MULTIPLE ROWS OF CABLE SHALL NOT EXCEED 3 ROWS IN BULKHEADS EXCEPT IN CONDENSED LOCATIONS IN WHICH ONLY 3 ROWS MAY BE USED ON REQUEST AND SUBJECT TO SPECIFIC APPROVAL.
 13. CABLE SUPPORT ANGLES BE 90, 120, 135, 150, 165, 180, 225, 270, 315, 360. FOLLOWING CABLES THE WELD SHALL BE 360 DEGREES. A. EXISTING TWO SUPPORTS OF TIE TYPE IS NOT CABLE JOINTS IN WET SPACES. B. WHEN THE WELLS ARE IN WET SPACES SUCH AS WEATHER DECK, SHOWER HEADS.

BUREAU OF SHIPS		WASHINGTON, D.C.	
ELECTRIC PLANT INSTALLATIONS		STANDARD METHODS	
GENERAL NOTES			
DATE	12/84	REVISION	1
SECTION	1	FIGURE	1
PROJECT	1000 6420273980 B		

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